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A STUDY ON DESIGN AND COST ANALYSIS OF A PROTOTYPE COAL CLEANING PLANT

PART I - VI

a report to

PROCESS CONTROL ENGINEERING DIVISION

NATIONAL AIR POLLUTION
CONTROL ADMINISTRATION

U. S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE

CONTRACT NO. PH 22-68-59

McNALLY PITTSBURG MANUFACTURING CORPORATION

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Out of 171 coals studied, only 21 are suitable for the reduction of sulfur by existing benefication methods. Sulfur in about 55 coals could be reduced to either less than 1.0% at a sacrifice in the yield (to less than 75%), or at a sacrifice of sulfur level, (i.e., 1.0% to 1.5% instead of less than 1.0%). At the present price levels for low sulfur coal, no coal company would be interested in making an investment to wash coals in this category unless a sufficient premium is given for low sulfur coal to compensate for the low yields of washed coal. Enforcement of more stringent anti-air pollution requirement would create a greater demand for low sulfur coals, which would surely raise low sulfur coal prices. Considering the capital investment and the operating costs of a 50 TPH prototype plant, offices and laboratories, the construction of a full scale commercial plant with a 50 TPH test circuit may be worth some consideration. From a cost standpoint, the administrative, office and laboratory personnel as well as the laboratory costs would be about the same for either a test plant or a commercial size plant. Moreover, a full scale plant with necessary test circuits would be of substantial value from both a scientific and commercial viewpoint; the possibility of operating the plant for its full life period would be of considerable commercial advantage.

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SYNOPSIS

PART I

PART I

SYNOPSIS

1. PURPOSE

Among the various pollutants in the air, oxides of sulfur (primarily SO_2 or sulfur dioxide) are the most common pollutants injurious to the health and detrimental to property values. Their sources are broad, but the majority of them come from thermal power plants and various other industries. Losses to property values alone amount to several billion dollars annually.

With the growth of cities and industries, the air pollution menace is increasing. It is estimated that by 1970, approximately 36 million tons of SO_2 are expected to be emitted into the atmosphere.

To combat the air pollution menace, Congress passed federal legislation on air pollution in 1955, the Clean Air Act in 1963 and finally the Air Quality Act in 1967. Under the Air Quality Act 57 air quality control regions have been designated on the basis of meteorological and topographical factors.

At present considerable work is being done in the following areas to control emission of SO_2 gas into the atmosphere:

a) Removal of sulfur compounds from coal before combustion;
b) Removal of SO_2 from the flue gas;
c) Location of low sulfur coal reserves; and
d) Change in in-process technology.

To investigate removal of sulfur compounds from the coal before it is burned, the U. S. Department of Health, Education and Welfare has awarded a contract, No. PH-22-68-59, to The McNally Pittsburg Manufacturing Corporation. Under this contract the following points were to be investigated:

a) To study approximately 200 sets of coal washability data from which to evaluate and classify coal suitable for producing a clean coal with different sulfur content;

b) To develop a scheme of ranking for these coals;

c) To develop a design for the most appropriate, conventional type coal cleaning plant to remove sulfur compounds;

d) To develop the installed cost of the plant, and estimated costs for the operation of the plant;

e) To develop test schedules for the evaluation of each coal to be processed in the plant;

f) And finally to estimate costs for the analysis of data to be generated in the prototype plant and develop flowsheets for full scale plants for the coals washed in the prototype plant.

2. ANALYSIS

From the washability data supplied by the Department of Health, Education and Welfare, 171 coals have been analyzed and categorized into the following six groups:

a) Raw coal having total sulfur less than 1.0%, 1.0% to 1.5% and 1.5% to 2.0%.

b) Raw coal cleanable to less than 1.0% total sulfur.

c) Raw coal cleanable to 1.0% to 1.5% total sulfur.

d) Raw coal cleanable to 1.5% to 2.0%.

e) Raw coal cleanable to 2.0% to 2.5%.

f) Raw coal not cleanable to less than 2.5%.

Under group (a) there are two coals with less than 1.0%, nine coals with between 1.0% to 1.5%, and fifteen coals with between 1.5% to 2.0% total sulfur. Two coals with less than 1.0% sulfur do not require washing for sulfur reduction. Since coals with 1.0% to 1.5% total sulfur can be utilized in most of the states within air pollution control limits, the nine coals with 1.0% to 1.5% sulfur would normally not require treatment for sulfur reduction. If required, seven coals out of nine can be washed to reduce the sulfur content to less than 1.0%.

For the groups (b) to (e) only, 3/8" x 0 size raw coal with a recovery of more than 75% washed coal has normally been included. If a 75% recovery for a given coal is not obtainable at that size, or is on the border line, it has been put into the next higher sulfur group. Washing at 14M x 0 has been considered only for those coals which fall in the sulfur group of 2.0% to 2.5%, as otherwise these coals will fall in the category of coal unwashable to less than 2.5%.

In group (b) thirteen coals are cleanable to less than 1.0% total sulfur. Under group (c) sulfur for twenty-three coals can be reduced to a 1.0% to 1.5% sulfur level. From group (d) twenty-two coals can be cleaned to the sulfur level of 1.5% to 2.0%. In group (e), the total sulfur for twenty-four coals can be reduced to 2.0% to 2.5%. In the last group, (f), seventy-eight coals are not cleanable to less than 2.5% total sulfur. The sulfur present in these coals is so finely disseminated that the reduction in the sulfur could be effected only at a great sacrifice in yield of clean coal, making washing uneconomical.

3. RANKING

A method has been developed for the three sizes of coal considered to show the theoretical recovery and the total sulfur content of clean coal from the washability data supplied. These three factors are considered in the following manner:

SIZE OF RAW COAL TREATED	NO.	RECOVERY OF CLEAN COAL	LETTER	TOTAL SULFUR IN CLEAN COAL	SUBSCRIPT
1½" x 0	1	75% to 100%	A	0% to 1.0%	1
3/8" x 0	2	50% to 75%	B	1.0% to 1.50%	2
14M x 0	3	0% to 50%	C	1.50% to 2.00%	3
				2.00% to 2.50%	4
				2.50% and Above	5

For example, a ranking of $1A_1$ means a 1-1/2" x 0 size raw coal with a possible yield of between 75% to 100% with a total sulfur of less than 1.0%. Similarly, $2B_3$ signifies a 3/8" x 0 size raw coal which when washed could yield 50% to 75% clean coal having a total sulfur of 1.5% to 2.0%.

Out of the 171 coals analyzed, twenty-two coals are considered to be "good", or in the A_1 Series; twenty-six coals are fair (Series A_2 or B_1); twenty-nine coals are average (Series A_3 or B_2 or C); and the remaining coals are poor or unwashable, due to either low yield in clean coal or high sulfur level in the clean coal.

4. PROTOTYPE PLANT (SEE FLOWSHEET & UNIT LIST, PAGES X & XI)

Keeping in view the complexity of washing these different coals with widely varying washability characteristics, the prototype plant should be designed with sufficient flexibility to remove sulfur from raw coal under a wide range of conditions. The plant recommended would be of 50 TPH capacity, and would have a coarse coal circuit with a heavy media cycloid for cleaning the various sizes of 1½" x 3/8", 1½" x 14M, 3/4" x 3/8", 3/4" x 14M and 3/8" x 14M coals; all fractions 3/8" and below would also be treated by the fine coal circuit.

Coals which should be crushed to 3/8" x 0 or 14M x 0 would be washed in the fine coal circuit having available primary and secondary McNally-Visman Tricones, ore and coal tables, and flotation cells. The pyrite recovery system would be provided with both ore tables and a secondary McNally-Visman Tricone, since the primary McNally-Visman Tricone is not only efficient in washing fine coals at a low gravity, but the secondary Tricone can also be used in treating high specific gravity material at a high cut point.

Besides the fine and coarse coal circuits, adequate arrangements have been made for unloading, handling, and crushing raw coal as well as handling of clean coal and disposal of refuse. There will be a water clarification system to reuse the clarified water in the washery. An 8000 ton capacity raw coal storage facility has been provided through two 4000 ton silos for storing sufficient raw coal for one month's operation.

The recommended prototype plant has been provided with alternate circuits and equipment choices which can be run in any combination so that it will be able to handle coals of different sizes with widely varying washability characteristics. In the absence of standard methods for the recovery of pyrite from the washery refuse, alternate circuits as well as alternate equipment are provided to determine the most suitable process for pyrite recovery from any given coal.

Although not included in the present plant design, the installation of a fluid bed type thermal dryer should be given consideration. The dryer could be used to process the fine coal with a high moisture content to provide valuable operating information. These data could then be used to assist coal cleaning plant, dust collector designers and operators to meet air pollution restrictions in the supply and operation of full scale plants and equipment.

To achieve the greatest good from this project, close cooperation from a large coal operator will be a great advantage. Taking this into consideration, help from the Peabody Coal Company has been arranged; they have offered the use of one of their idle coal preparation plants near Terre Haute, Indiana, for this project. Peabody Coal Company has also agreed to extend the necessary help to direct the work and operate the plant by men experienced in the coal preparation work.

The site is easily accessible, and all the facilities such as ground space for additional clean coal storage, a more than adequate refuse disposal pond, a large fresh water pond, and utility services are available. The plant site also has adequate free space available for a future roasting and chemical plant for processing the recovered pyrite from the washery refuse.

5. OBJECTIVES

The object of the prototype plant is to generate information on the reduction of sulfur for a given coal. Keeping this in view, adequate sampling and testing arrangements have been provided to evaluate each coal selected for washing. The plant will have twenty-nine (29) sampling points--twenty-seven (27) automatic pulp and solid samplers and two (2) manual sampling arrangements.

The purpose of the testing program is to: (1) evaluate each coal selected for washing; (2) evaluate performance of each piece of equipment used in the plant; (3) select the proper circuit for a given coal; (4) evaluate overall performances of the plant for cost analysis; and (5) to make comprehensive plant studies including material, ash, and sulfur balances for each coal.

The test schedule calls for optimum adjustment for most efficient operation of each piece of equipment as well as for each separate circuit in the plant. After the equipment and the circuits are set for their best performance in sulfur reduction, prolonged test runs will be made with all the sampling stations of all the circuits in use so that a complete plant evaluation can be made for each coal washed.

The plant feed and final products for each coal will have complete ultimate and proximate analysis to determine the burning and slagging characteristics of the feed as well as for the final products. Regular checks will also be made on the plant effluent as well as on any pond water or streams which might be affected by the plant operation.

In the course of cleaning and testing various coals valuable information will be generated on the reduction of sulfur. Information will also be produced on the performance of the individual pieces of equipment, suitability of different circuits, and the overall performance of the plant. All of this information should be properly cataloged and stored for ready access. With this in view, Micro-Filming arrangement together with an adequate storage and retrieval system has been suggested. Closed circuit TV communication will also be provided for confidential transmission of data to the plant and laboratory operations.

6. CAPITAL & OPERATING COSTS

As indicated above, the recommended prototype plant has been designed with both a fully equipped testing laboratory, an analytical laboratory and suitable office facilities have been provided. Operation of this plant with extensive laboratory facilities is expected to be expensive. The following cost analysis on the operation of the plant and the laboratory has been done on the basis of one year installation time, six months for start-up and three years for actual operation. Estimated costs are:

	LABORATORY & OFFICE	PLANT	TOTAL
Estimated capital investment for equipment & installation	$ 1,078,191	$ 2,158,000	$ 3,236,191
Six months start-up costs	$ 911,514	$ 253,335	$ 1,164,849
Operating costs for 3 years	$ 5,430,000	$ 1,520,010	$ 6,950,010
Insurance for 4-1/2 years	$ 11,540	$ 44,185	$ 55,725
	$ 7,431,245	$ 3,975,530	$ 11,406,775

Depreciated value of the plant and laboratory equipment at the end of 4-1/2 years has been assumed to be 10% of the capital investment, or $323,619.

Cost of 96,000 tons of raw coal (washed at half the rated capacity during the start-up period and at 50 TPH for three years) is estimated at $3,276,000; the sale price of washed coal is estimated at $995,163.

7. POSSIBLE FUTURE USE OF FACILITY

In view of the possible future benefits of such a flexible coal cleaning and testing facility and especially considering the contemplated capital investment, it is recommended that some thought be given to the use of this facility well beyond the length of the present program for future testing and development. One would hope that there might be substantial side benefits and some new developments in different phases of coal technology, possibly through improvements to or extension of present methods;

more likely these improvements could come through the use of chemical engineering techniques for the further reduction of sulfur and/or ash from the more difficult to clean coals.

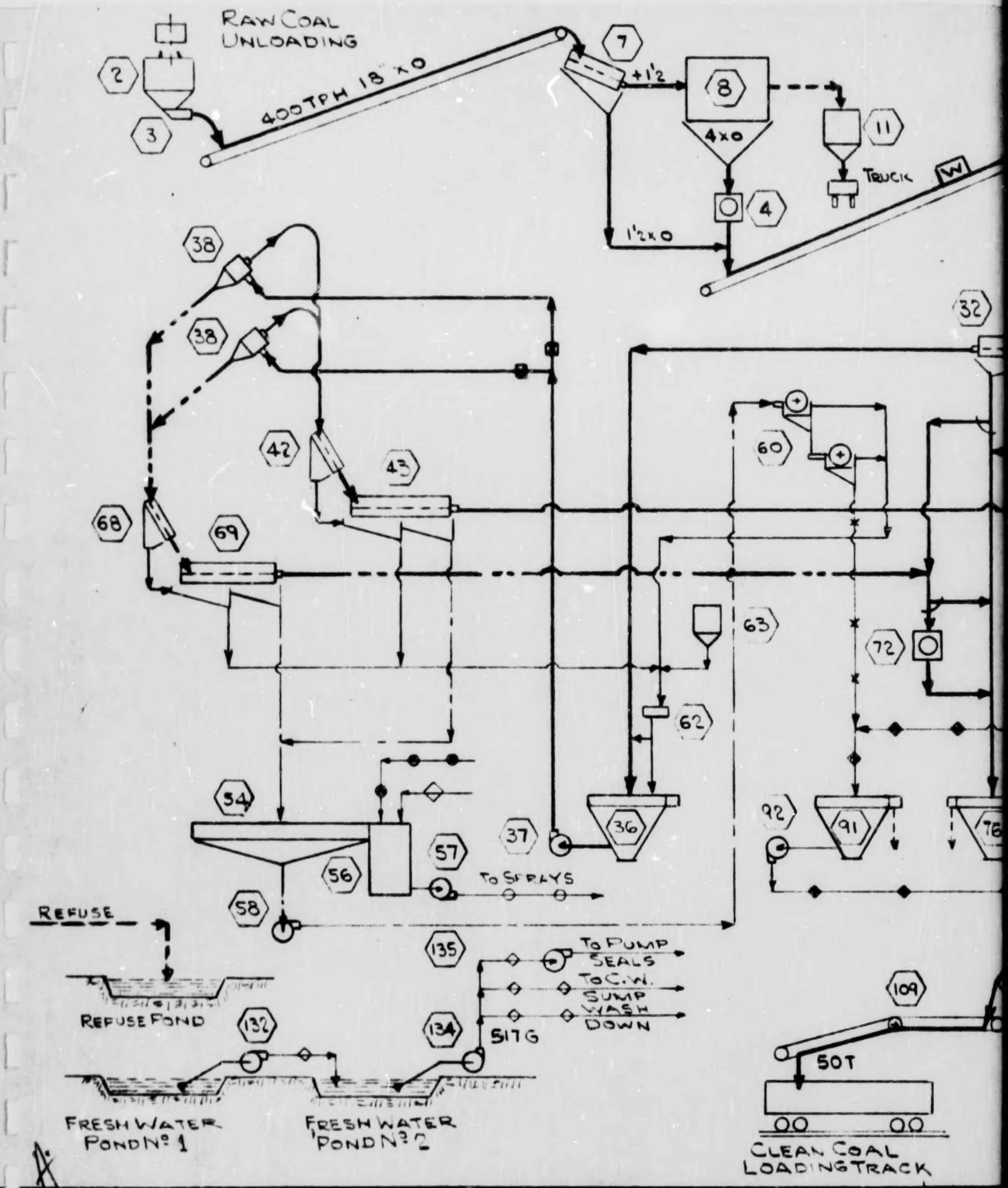
8. CONCLUSIONS & RECOMMENDATIONS

To meet the air pollution requirement, extensive work is being done in this country to find improved methods for the reduction of sulfur present in the coal. With existing methods, sulfur in coal can be removed either before combustion or during combustion, or from the flue gas after the coal is burned. Until improved and more efficient methods are found, a part of the sulfur (and ash) in the coal can be removed before burning by the beneficiation methods currently in use. The success of the reduction of sulfur by the existing beneficiation methods is dependent upon the nature of occurrence of sulfur in the coal and upon its ease of removal. Only 21 coals of 171 coals studied fall within this category.

Sulfur in about 55 coals could be reduced to either less than 1.0% at a sacrifice in the yield (to less than 75%), or at a sacrifice of sulfur level, (i.e., 1.0% to 1.5% instead of less than 1.0%). At the present price levels for low sulfur coal, no coal company would be interested in making an investment to wash coals in this category unless a sufficient premium is given for low sulfur coal to compensate for the low yields of washed coal. Enforcement of more stringent anti-air pollution requirement would create a greater demand for low sulfur coals, which would surely raise low sulfur coal prices.

Considering the capital investment and the operating costs of a 50 TPH prototype plant, offices and laboratories, the construction of a full scale commercial plant with a 50 TPH test circuit may be worth some consideration. From a cost standpoint, the administrative, office and laboratory personnel as well as the laboratory costs would be about the same for either a test plant or a commercial size plant.

Moreover, a full scale plant with necessary test circuits would be of substantial value from both a scientific and commercial viewpoint; the possibility of operating the plant for its full life period would be of considerable commercial advantage. Further discussion of this subject is given in the body of the report.


RAW COAL
UNLOADING
2
3
400 TPH 18" x 0
7
+1½
8
4x0
4
1½x0
11
TRUCK
W
38
38
42
43
68
69
60
63
72
62
32
54
56
57
58
37
36
92
91
78
TO SPRAYS
REFUSE
REFUSE POND
135
TO PUMP
SEALS
TO C.W.
SUMP
WASH
DOWN
134
517 G
132
FRESH WATER
POND Nº 1
FRESH WATER
POND Nº 2
109
50T
CLEAN COAL
LOADING TRACK

DESCRIPTION OF REVISION EXCEPT FOR ISSUE 1	MADE BY	CHECKED BY	APPROVED BY	DATE
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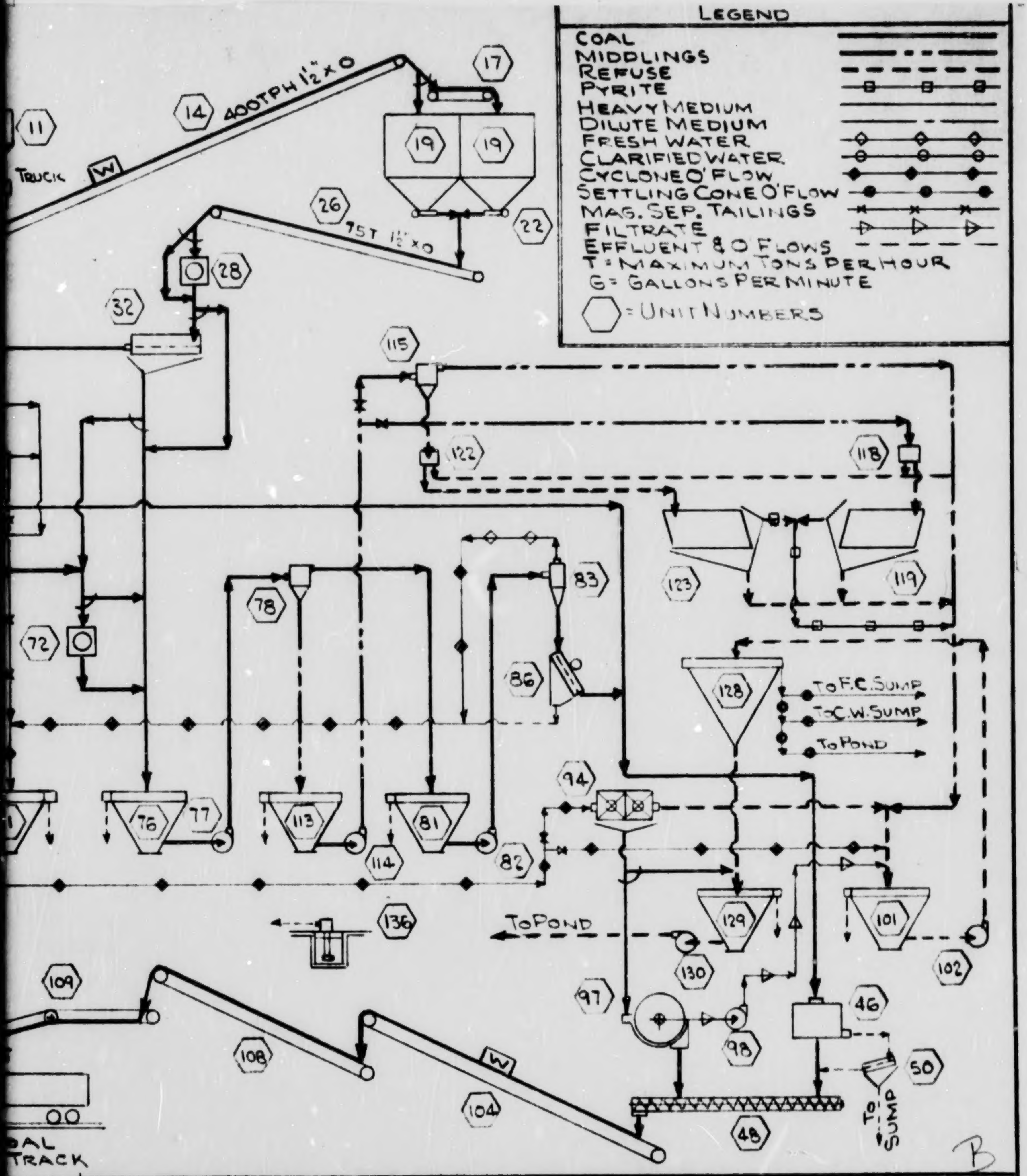
LEGEND
COAL
MIDDLINGS
REFUSE
PYRITE
HEAVY MEDIUM
DILUTE MEDIUM
FRESH WATER
CLARIFIED WATER
CYCLONE O'FLOW
SETTLING CONE O'FLOW
MAG. SEP. TAILINGS
FILTRATE
EFFLUENT & O'FLOWS
T = MAXIMUM TONS PER HOUR
G = GALLONS PER MINUTE
= UNIT NUMBERS
11
14
400TPH 1½"×0
17
19
19
TRUCK
W
26
75T 1½"×0
22
28
32
115
122
118
123
119
78
83
72
86
128
To F.C. SUMP
To C.W. SUMP
To POND
94
76
77
113
81
114
82
129
101
136
To POND
130
102
109
97
98
46
108
104
W
50
48
To SUMP
OAL
TRACK
B

PROPOSED COAL PREPARATION PILOT PLANT
FLOW DIAGRAM
FOR DEPARTMENT OF HEALTH, EDUCATION
AND WELFARE

8-8-69

APPROVED BY
DATE

SCALE
NONE
= 1 FT.

ISSUE
1

UNIT NO. — SALES ORDER NO.
- 62521
(END USE NUMBER)

DRAWING NUMBER
C-4527-A

10. LIST OF EQUIPMENT UNIT NUMBER SHOWN IN FLOW DIAGRAM C-4527-A

UNIT	DESCRIPTION	UNIT	DESCRIPTION
2	R.O.M. Hopper	76	Fine Coal Sump
3	R.O.M. Feeder	77	Fine Coal Pump
4	Raw Coal Crusher	78	Primary Tricones
7	R.O.M. Screen	81	Classifying Cyclone Sump
8	Rotary Breaker	82	Classifying Cyclone Pump
11	Rock Bin	83	Classifying Cyclones
14	Raw Coal Storage Belt	86	Cross Flow Screen
17	Raw Coal Transfer Conv.	91	Flotation Sump
19	Raw Coal Bins	92	Flotation Pump
22	R.C. Feeders	94	Flotation Cells
26	Washery Feed Conveyor	97	Clean Coal Filter
28	Raw Coal Crusher	98	Filter Auxiliaries
32	Raw Coal Screen	101	Tailing Sump
36	Cycloid Feed Sump	102	Tailing Pump
37	Cycloid Feed Pump	104	W.C. Belt
38	Heavy Medium Cycloids	108	Clean Coal Conveyor
42	Cross Flow Screen	109	Loading Boom
43	Float Screen	113	Secondary F.C. Sump
46	Clean Coal Centrifuge	114	Secondary F.C. Pump
48	Clean Coal Screw	115	Secondary Tricones
50	Tell-Tale Screen	118	Table Distributor
54	Dilute Medium Thickener	119	Deister Coal Table
56	Clarified Water Sump	122	Rotary Distributor
57	Clarified Water Pump	123	Deister Ore Tables
58	Magnetic Separator Pump	128	50' Dia. Cone
60	Magnetic Separator	129	Refuse Sump
62	Heavy Medium Controls	130	Refuse Pump
63	Magnetite Bin	132	Fresh Water Pump
68	Cross Flow Screen	134	Fresh Water Pump
69	Sink Screen	135	Seal Water Pump
72	Secondary Crusher	136	Sump Pumps

NOTE: Only those equipment items shown on the flowsheet are listed; a complete list of equipment is given in Part VII, Pages D.O. to D.4.

OBJECT OF STUDY

PART II

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PART II

OBJECT OF STUDY

1. AIR POLLUTION LAW

In the year 1955 the first Federal legislation on Air Pollution was passed, in the Eighty-Eighth Congress. It created Public Law 88-206, its object being to cause the removal of those pollutants from the air which are hazardous to health, vegetation and property. Again in the year 1963 another, more stringent clean air act was passed. To implement these laws, the Federal Government, through the efforts of the Health, Education and Welfare Department, is moving to establish effective standards for the control of air pollution on a nationwide basis. In view of the new legislation, the U.S. Department of Health, Education and Welfare has been made responsible to develop ways and means to remove sources of pollutants either before combustion or after. Under the Air Pollution Control Program, McNally Pittsburg has been awarded Contract No. PH-22-68-59 to investigate various high and low sulfur coals and to develop an appropriate plant design to produce low sulfur coal by conventional coal cleaning methods.

Subsequently, the Air Quality Act passed in 1967 requires that the Federal Government advise all state authorities on the criteria of the effects of pollutants on the health and property. The Act also stipulates that the state authorities are to be advised on the most effective and economical methods of controlling pollutants. The National Air Pollution Control Administration, Division of HEW, has set as their target that the Air Quality Act of 1967 will be implemented by the summer of 1970. Responsibility of enforcement of the program under the Act will be placed squarely on the shoulders of the state authorities with supplemental help and guidance from the regional office of the Department of HEW.

A total of 57 air quality control regions have now been designated under this ambitious program. In each area regional boundaries are drawn on the basis of meteorological and topographical factors. State authorities are required to set up their own air quality standards for any portion of their territory falling within the air quality control regions under this Act.

2. SOURCES OF AIR POLLUTION

There are many varieties of gases and materials which pollute the air. The primary pollutants, however, are hydrocarbons, oxides of sulfur, oxides of nitrogen, oxides of carbon and fine particles. Their sources are also broad but the majority of them come from internal combustion engines and various industries which are primarily responsible for oxides of sulfur, oxides of carbon, oxides of nitrogen, etc.

In spite of legislation on air pollution control, the Clean Air Act and the Air Quality Act, the nation's air pollution problem is becoming steadily worse. Pollutants in the air not only damage property and endanger health, they are harmful for farm crops and many kinds of vegetation. Losses to property values, to crops and vegetation amount to several billion dollars annually. Apart from the monetary losses for property, farm crops and other vegetation, there is also a considerable hazard to health due to continuous exposure to polluted air.

3. PRODUCTION & CONSUMPTION OF COAL IN THE UNITED STATES

Coal and fuel oil are the principal sources of oxides of sulfur. Listed below are statistics on the production and combustion of lignite and bituminous coal for the last four years, given in millions of tons:

	Production	Consumption by Power Plants	Consumption by Other Industries
1965	515 M Tons	243 M Tons	197 M Tons
1966	538 M Tons	264 M Tons	202 M Tons
1967	557 M Tons	272 M Tons	191 M Tons
1968	545 M Tons	295 M Tons	189 M Tons

The consumption of coal (26) is expected to grow as follows:

1970	600 M Tons
1980	670 M Tons
1990	890 M Tons
2000	1200 M Tons

NOTE: Numerical number in parenthesis refers to bibliographic reference. See Pages 76 and 77.

Electric utilities have been the largest single consumer of coal since the late 1940's. With the growth of cities and industries and a higher standard of living, consumption of electricity per capita is increasing; consequently the consumption of coal by power plants will continue to expand. It is estimated that by the year 2000, power plants in the country will utilize approximately 600M Tons, or half of the above estimated 1200 M Tons, of coal per year.

The above figures also show that by 1970, 600,000,000 tons of raw coal, having an average 3% sulfur, will therefore burn approximately 18,000,000 tons of sulfur to release approximately 36,000,000 tons of SO_2 gas into the air. This illustrates the magnitude of air pollution problem due to SO_2 alone, not to mention the pollutants like other hydrocarbons, nitrogen oxides, carbon dioxide, etc. Present figures show that more than 20,000,000 tons of SO_2 gases are being emitted into the atmosphere annually.

4. OCCURANCE OF SULFUR IN COAL

Sulfur is found in raw coal in the following different forms:

Free Sulfur
Organic Sulfur
Pyritic Sulfur
Sulfate Sulfur

Occurrence of free sulfur has been reported in some coals but it is generally disregarded because it exists in only minute quantities. The amount of sulfate sulfur present in the coal varies considerably; it increases rapidly with the weathering of coal due to the oxidation of the pyrite. Pyritic sulfur occurs in coal either as pyrite or marcasite. Organic sulfur in general occurs in coal in a finely mixed condition and it is considered as an inherent constituent of coal. As organic sulfur is intimately mixed with coal, it is difficult to reduce by beneficiation when using conventional methods.

Pyrite occurs in coal in bands, in pockets, or as particles, fine or coarse, mixed with the coal. Pyrite in bands or pockets or as coarse particles is easy to separate by mechanical means. Fine pyrite particles when intimately mixed with the coal are considered to be inherent and are difficult to remove by conventional methods.

The total sulfur content of U.S. coals ranges from 0.20 to 7.0 percent on a dry basis. Pyritic sulfur ranges from 40% to 80% of total sulfur. Generally, organic sulfur predominates in the low sulfur coals.

5. REMOVAL OF SULFUR FROM COAL

During World Wars I and II pyrite from coal was recovered in some countries to augment their sulfur supply. Most of the pyrite recovery plants operated successfully during the war days but eventually closed down for economic reasons rather than for technical reason. At present efforts are again being made to remove sulfur from coal either as SO_2 gas or as a sulfur compound, not due to a shortage of sulfur, but to eliminate the SO_2 gas -- one of the major sources of air pollution.

Currently, research towards the reduction of air pollution due to the presence of sulfur in oil and coal are being directed along the following lines:

(a) Removal of SO_2 gas after combustion;
(b) Removal of sulfur compounds from the fuel before burning;
(c) Locate fresh reserves of low sulfur coal; and
(d) Change in technology of producing electricity from coal.

In the processes (a) and (b), research is aimed toward the recovery of sulfur either as a gas or as a solid for commercial utilization. EXAMPLE: Sulfuric acid. In the process (d), attempts are being made to convert coal directly into electricity with consequent elimination of thermal pollution.

The scope of this contract, as described in the following pages, covers process (b), i.e., the removal of sulfur from coals before burning. Following are the different processes available:

A. Removal of sulfur compounds through conventional mechanical cleaning processes.
B. Carbonization or gasification of coal.
C. Solvent extraction of sulfur from low sulfur coal.

None of these processes, except the first one, has reached commercial status; the others are still under development. Our contract has therefore been devoted to Process A.

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PART III

TECHNOLOGICAL REVIEW

SECTION 1

SCOPE OF WORK

The scope of work comprises the following:

I. Study approximately 200 sets of coal washability data from which to evaluate and identify coals suitable for producing a clean coal having a total sulfur content of:

   a) Less than 1.0%
   b) 1.0% to 1.5%
   c) 1.5% to 2.0%
   d) 2.0% to 2.5%
   e) Above 2.5%

II. To develop a ranking of coals most appropriate for evaluation in the prototype plant.

III. To develop a design for the most appropriate prototype cleaning plant to remove pyritic sulfur from raw coal under a wide range of conditions.

IV. To select a suitable site based upon the following:

   a. Operational expenses
   b. Location of coals to be studied
   c. Availability of outlets for the cleaned coal
   d. Facilities for refuse disposal and/or storage of refuse for future evaluation
   e. Availability of coal handling facilities
   f. Availability of necessary services
   g. Requirements for and availability of manpower
   h. Coal testing and analysis facilities
   i. Nature of arrangements which can be made for use of the land

V. To develop the installed cost of a prototype plant including the following:

   a. Flow sheet of the process
   b. Equipment and its specifications

VI. To develop a complete test schedule for the evaluation of each coal selected for processing in the prototype plant.

VII. To develop a total estimated cost for conducting the research, including the following items:

a. Detail design costs
b. Equipment costs
c. Construction costs
d. Cost for use of land
e. Procurement and transfer of feed coal
f. Cost of disposal of waste
g. Cost of storage of reject products for possible use in the prototype chemical conversion process
h. Credits for clean coal products
i. Operating cost for the prototype plant including necessary test facilities for process evaluations and quality control requirements
j. Costs of services and utilities
k. Cost of prototype plant disposal and land restoration that may be required at completion of research operations
l. Develop estimated cost for analysis of data to be generated by the prototype study and estimated cost to develop flow sheets and cost estimates for a full-scale plant.

Besides the above, the Contract also calls for the study of the pyrite-coal concentration for pyrite-coal-ash utilization processes. Concentration requirements could not be considered, however, since HEW has as yet been unable to define the concentration requirement. As a result, a most flexible coal preparation plant with several alternate coal cleaning processes has been designed. With this design it will have various techniques available for the recovery of pyrite from the plant refuse.

SECTION 2

PROJECT ANALYSIS WORK

From the washability data generated by the Commercial Testing and Engineering Company and the U. S. Bureau of Mines, approximately 200 coals have been analyzed and categorized into six groups:

1. Raw coal having total sulfur less than 1.0%, 1.0% to 1.50%, and 1.50% to 2.0%.
2. Raw coal cleanable to less than 1.0% total sulfur.
3. Raw coal cleanable to 1.0% to 1.5% total sulfur.
4. Raw coal cleanable to 1.5% to 2.0% total sulfur.
5. Raw coal cleanable to 2.0% to 2.5% total sulfur.
6. Raw coal not cleanable to less than 2.5% total sulfur.

A. Raw Coal With Low Sulfur Content

Table I shows a grouping of the raw coals whose total sulfur content is less than 1.0%, 1.0% to 1.5%, and 1.5% to 2.0%. It can be seen from Table I, Page 1, that raw coal (CT-63 in Pennsylvania) has 0.71% total sulfur. Although this sulfur content could be reduced to 0.69% by washing at 1.90 Sp. Gr. recovering 98.6% clean coal, it would not be economical to do so. The 0.63% total sulfur in the raw coal (BM-93 in Alabama) could not be reduced on washing. In these two coals, the sulfur present is principally in organic form and whatever pyritic sulfur present is so intimately mixed that it could not be reduced by beneficiation. It would obviously not be worthwhile in these two cases to attempt to reduce the already low sulfur level.

The total sulfur content of nine of the raw coals (BM-94 in Alabama; CT-3, CT-49, BM-96 and BM-49 in Pennsylvania; BM-103 in West Virginia; and CT-58, BM-16 and CT-60 in Illinois) shown in Table I, Pages 1 and 2, is between 1.0% to 1.5%. These coals can be utilized in most states of the U.S.A. within air pollution control limits. In all of these cases, except for BM-103 and CT-58, the sulfur content could be reduced to less than 1.0%. The washability data on CT-58 and BM-103 show that the sulfur constituent is so intimately mixed that it could not be reduced to less than 1.0%, even by crushing it to 14M x 0. It would, therefore, only be economical to use this

NOTE: CT and BM indicated in parenthesis refer to samples taken by Commercial Testing & Engineering Company and U. S. Bureau of Mines respectively. See Appendix A to F.

CT-58 coal raw. Table I, Pages 3, 4 and 5, also show that fifteen coals (BM-91 and BM-95 in West Virginia; CT-16, CT-19, CT-32, CT-28, BM-39, BM-44 and BM-51 in Pennsylvania; CT-21 and BM-19 in West Virginia; BM-29 and CT-40 in Ohio; and BM-67 and BM-70 in Indiana) have a total sulfur content of between 1.5% and 2.0%. A washability analysis of the available data shows that sulfur in nine out of fifteen coals (CT-16, CT-19, BM-51, CT-21, CT-40, BM-67, CT-32, CT-28 and BM-39) could be reduced to less than 1.0% total sulfur on washing 3/8" x 0 size coal. But the clean coal recovery of three (CT-32, CT-28 and BM-39) of these coals is quite low, making it uneconomical to reduce the sulfur to less than 1.0%. It would, therefore, be advisable to wash these three coals to within a 1.0% to 1.5% sulfur limit. Sulfur of four coals (BM-44, BM-91, BM-95 and BM-19) out of the six remaining could not be reduced to less than 1% even on crushing to 14M x 0. These four coals, therefore, can be used economically only at a 1.0% - 1.5% sulfur level. The washability analysis indicates that the remaining two coals (BM-29 and BM-70) could be reduced to less than 1.0% by washing at 14M x 0 size; in any case, however, crushing of raw coal to 14M x 0 to reduce the sulfur must be considered carefully from an economical standpoint.

B. Raw Coal With Higher Sulfur Content

All other coals whose washability data have been supplied by HEW are shown in Tables II, III, IV, V and VI based on the total sulfur that could be logically attained by washing. Categorization of coals from the washability data has been made based upon the following:

(a) Theoretical recovery of total sulfur as indicated by the washability data.

(b) In general, being the nearest to an average condition, washability of 3/8" x 0 size coal has been used as a guide more often than 1-1/2" x 0 or 14M x 0 sizes in making the groups. The 1-1/2" x 0 size has been considered when a satisfactory result is obtainable without crushing to 3/8" x 0. The 14M x 0 size was considered only when 1½" x 0 and 3/8" x 0 sizes did not yield satisfactory results.

(c) Washed coal with a satisfactory recovery at an acceptable total sulfur level has been the main consideration in categorizing coals into different groups.

(d) In case of low recovery of washed coal (in the lowest possible sulfur range), the same coal has also been included in the next higher sulfur group yielding a higher recovery of washed coal. To explain, coal from CT-32 (Pennsylvania) on washing at 1.30 Sp. Gr. yields only 37.3% washed coal with 0.96% total sulfur. Since such a low recovery will make washing uneconomical, it was considered in the next higher sulfur range of 1.0%-1.5% total sulfur. In this case, the theoretical recovery of washed coal would be 75.1% with 1.16% total sulfur when washed at 1.90 Sp. Gr.

(e) Similarly washed coal with total sulfur on the border line has also been included in the next higher sulfur group. For example, coal from CT-52 (Ohio) would theoretically yield 68.6% washed coal with 0.97% total sulfur content at 1.30 Sp. Gr. Since in actual washing at 1.30 Sp. Gr., the washed coal sulfur would likely be more than 0.97%, it was also considered for washing at a higher Sp. Gr. of 1.40 to yield theoretically 85.2% washed coal having 1.30% total sulfur.

(f) In case it is not possible to attain a satisfactory yield at an acceptable recovery, the sulfur content from 1½" x 0 or 3/8" x 0 size coal, 14M x 0 size has been considered; the same coal has also been included in the next higher sulfur group for washing at 3/8" x 0 size. To take an example, the coal from BM-31 of Iowa State (Table II, Page2) yields 89.2% washed coal with 0.94% total sulfur when crushed to 14M x 0. When crushed to 3/8" x 0 size, the washed coal has 1.3% total sulfur when washed at 1.30 Sp. Gr., with a yield of only 69.7%.

Tables II to VI show raw coals and theoretical yields of the washed coals, total sulfur, pyritic sulfur and ash percentage from an analysis of the Department of Health, Education and Welfare data.

g) Our study of 26 Illinois coals washability data reveals that, in general, Illinois coals are high in sulfur. Total sulfur in the raw coals studied varies between approximately 1.0% to 8.0%. The sulfur exists as either organic or pyritic in a disseminated form, which makes reduction of sulfur impossible by current beneficiation methods. Out of 26 raw coals, three contain total sulfur as low as 1.0%-1.5% and these would be the only raw coals within the state which fall within the present/proposed air pollution control limits. From the balance of 23 coals, four can be washed to a sulfur level of between 1.5% to 2.0%, two to a sulfur level of 2.0% to 2.5%; for the remaining 17 coals the sulfur level cannot be reduced to less than 2.5%.

This situation obviously poses some difficult problems for the coal consumers, the coal operators and the air pollution control authorities. At this stage of coal technology when most Illinois coals cannot be reduced to a 1.5% sulfur level by conventional beneficiation processes it appears that there may be a difficult economical period for coal consumers and producers during which time most of their coal will have to be imported from other states. This period could extend until economical methods are developed and put into commercial use for reducing or removing sulfur from coal, likely with an end result of converting coal to gas and/or liquid fuels. Similar conditions, although not as severe, may exist in other areas of the country.

SECTION 3

EFFECT OF CRUSHING UPON THE LIBERATION OF PYRITE

The size of mineral particles and their distribution in raw coal is fundamental to washability characteristics of a coal. Pyrite is one of the constituents of mineral matter present in coal and its removal is necessary to reduce a coal's total sulfur content. Removal of pyrite by conventional coal cleaning process depends upon its characteristics as it occurs in the raw coal and the effect of crushing upon its liberation. The following studies have been made on the effect of crushing upon the liberation of pyrite for various coals crushed to three different sizes. 1½" x 0, 3/8" x 0 and 14M x 0.

Table in Page 12 illustrates the effect of crushing upon the liberation of pyritic sulfur from Ohio's Seam No. 6. This coal was crushed to 1½" x 0 and 3/8" x 0. Reduction of size from 1½" x 0 to 3/8" x 0 shows the release of pyritic sulfur making it possible to recover, theoretically, 89.78% washed coal at 0.98% total sulfur by washing 3/8" x 0 size coal; only 67.98% washed coal could be theoretically recovered with 0.97% total sulfur from 1½" x 0 size coal. Recoveries of washed coal at different theoretical total sulfur levels for both 1½" x 0 and 3/8" x 0 size coal are shown by the curve in Figure 1.

Figures 2 and 3 show other curves which illustrate the effect of crushing upon the liberation of pyritic sulfur (for the coals from CT-7 and BM-58 in Ohio). Figures 4 and 5 have curves which show that, while there is a considerable liberation of sulfur (pyritic) when crushing coal (from CT-41 and CT-24 in Ohio) from 1½" x 0 to 3/8" x 0, there is hardly any effect when crushing the same coal from 3/8" x 0 to 14M x 0. The curves for Figures 4 and 5 serve to show that the total sulfur present in 3/8" x 0 size coal is more or less inherent in nature and cannot be liberated by further crushing.

In the same context, Figure 6 curves show that coal (from BM-105 in Ohio) on crushing from 1½" x 0 to 3/8" x 0 does not liberate an appreciable amount of sulfur; however, as the curves indicate, the same coal when crushed to 14M x 0 does release further sulfur

Table

Effect of Crushing Upon the Liberation of Pyrite, Ohio #6 Bed

	1½" x 100M			3/8" x 100M		
Sp. Gr.	Wt. %	Pyrite	T. Sulf.	Wt. %	Pyrite	T. Sulf.
1.30	38.91	0.24	0.76	51.14	0.14	0.62
1.30-1.35	67.98	0.43	0.97	73.23	0.21	0.72
1.35-1.40	80.99	0.55	1.11	81.46	0.27	0.79
1.40-1.45	85.61	0.66	1.21	85.33	0.33	0.85
1.45-1.50	87.96	0.72	1.27	87.37	0.37	0.89
1.50-1.60	90.40	0.84	1.39	89.78	0.45	0.98
1.60-1.70	92.18	0.92	1.47	91.30	0.52	1.04
1.70-1.80	92.86	0.97	1.52	91.92	0.56	1.08
1.80-1.90	93.47	1.02	1.58	92.56	0.61	1.13
1.90-2.00	94.08	1.08	1.64	93.11	0.66	1.18
2.00-2.20	95.14	1.17	1.73	94.08	0.75	1.28
2.20-2.40	96.11	1.26	1.82	95.79	0.91	1.45
2.40-2.60	97.76	1.35	1.90	97.16	0.99	1.52
2.60-2.80	99.13	1.46	2.01	98.23	1.08	1.62
2.80-3.30	99.51	1.58	2.14	98.99	1.33	1.88
2.20	100.00	1.77	2.34	100.00	1.74	2.31

FIG. 1

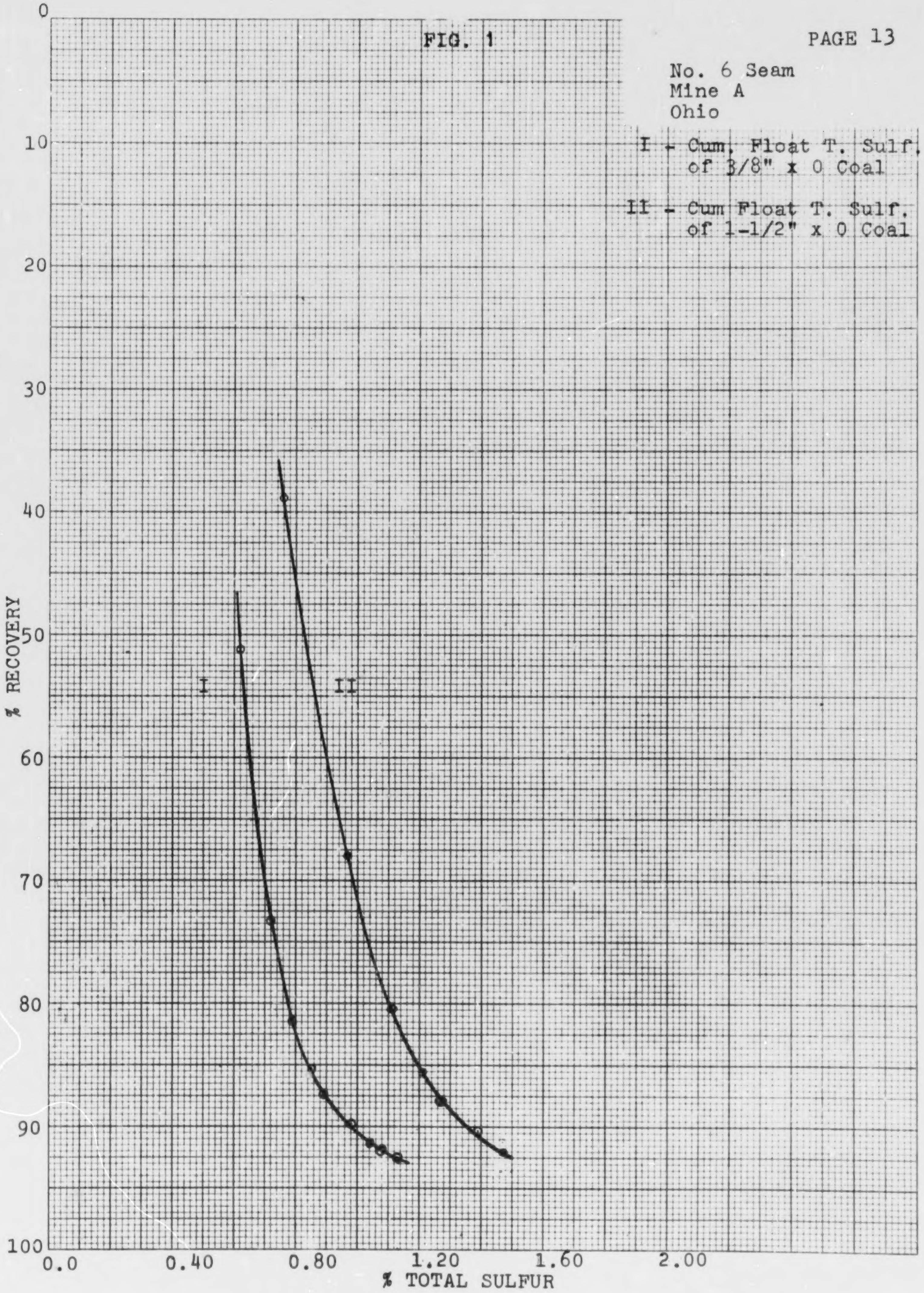
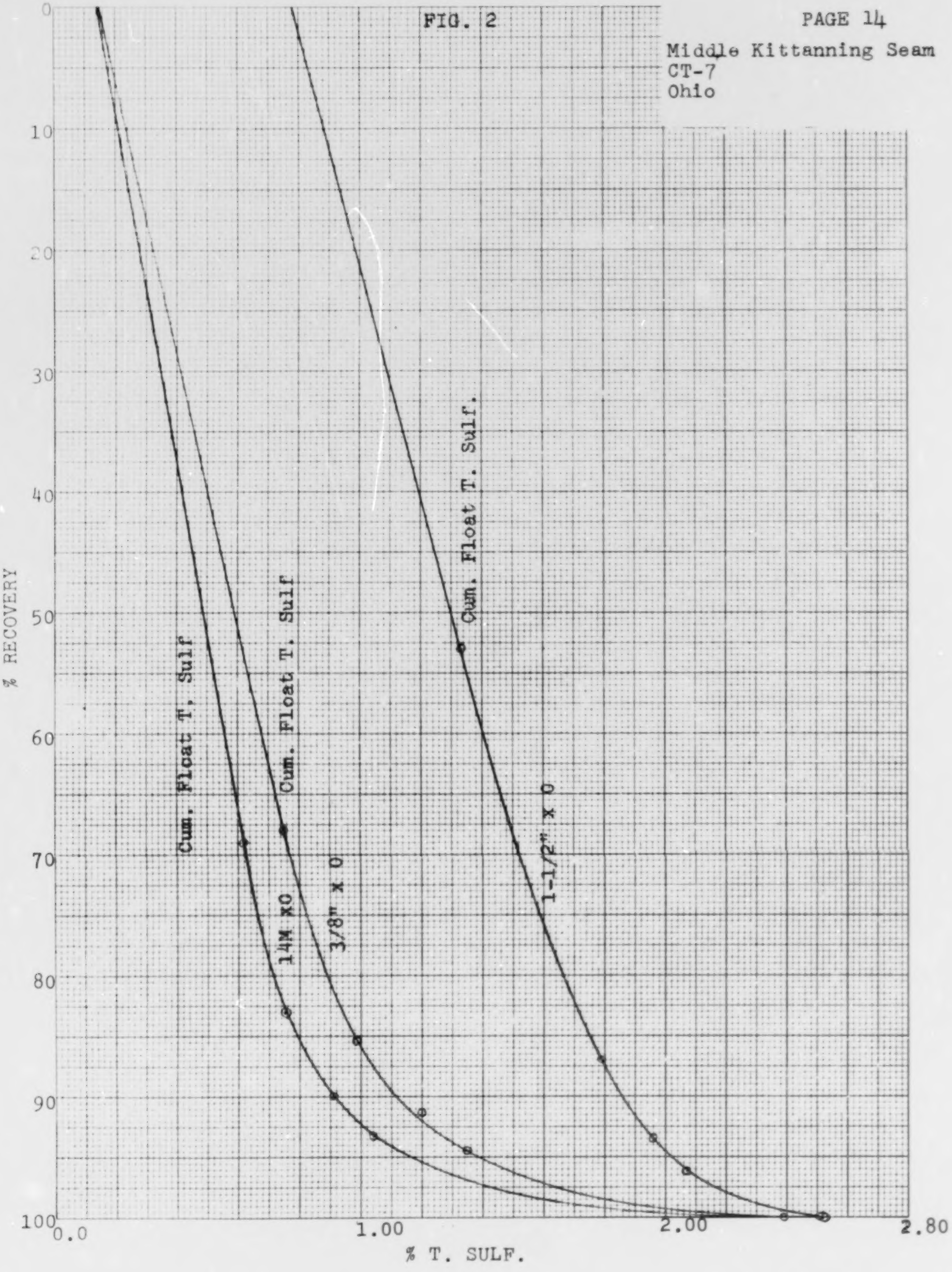

No. 6 Seam
Mine A
Ohio
I - Cum. Float T. Sulf. of 3/8" x 0 Coal
II - Cum Float T. Sulf. of 1-1/2" x 0 Coal
I
II
% RECOVERY
0
10
20
30
40
50
60
70
80
90
100
0.0
0.40
0.80
1.20
1.60
2.00
% TOTAL SULFUR

FIG. 2

Middle Kittanning Seam
CT-7
Ohio



Pittsburgh Seam
BM-58
Ohio

FIG. 3

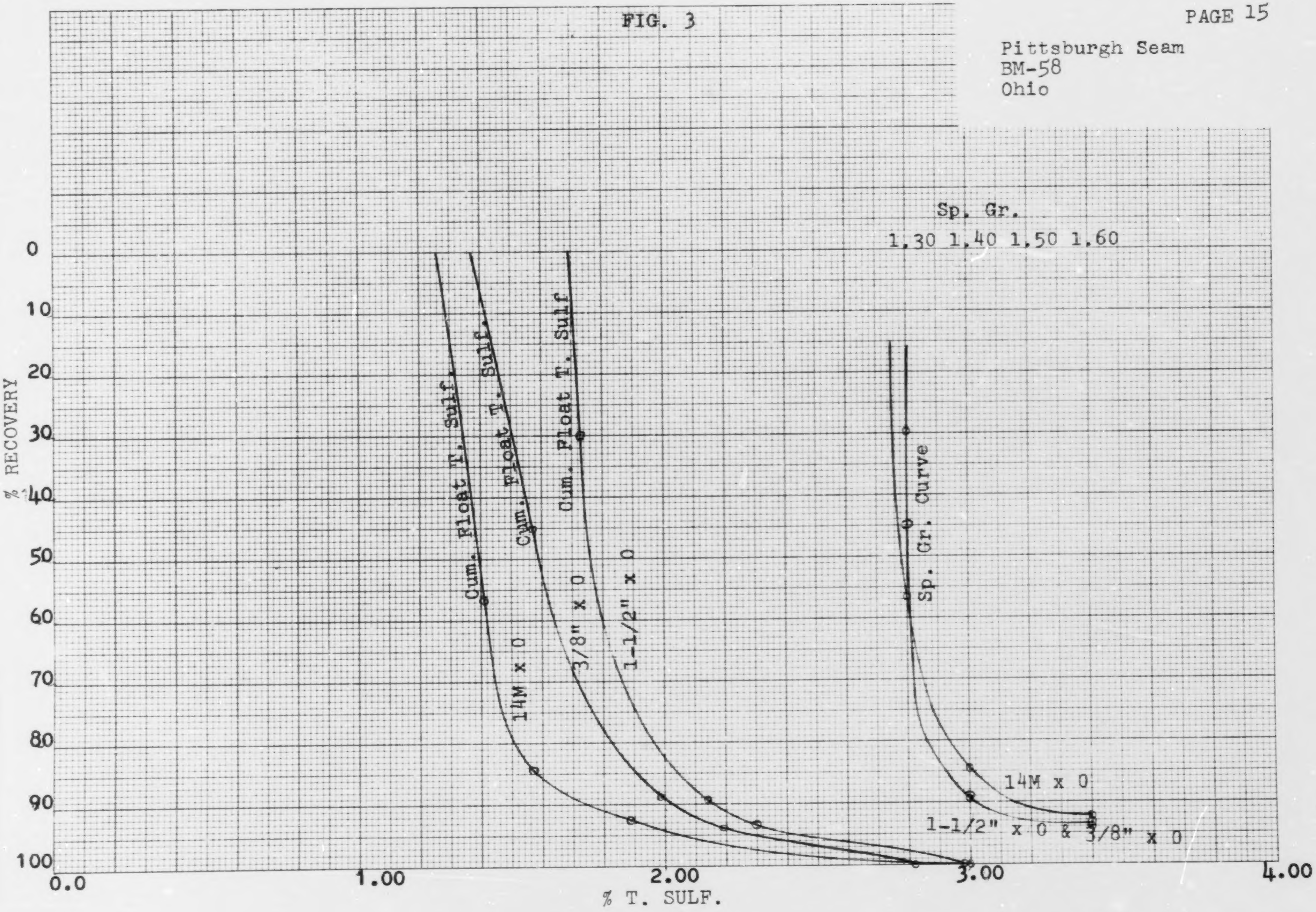
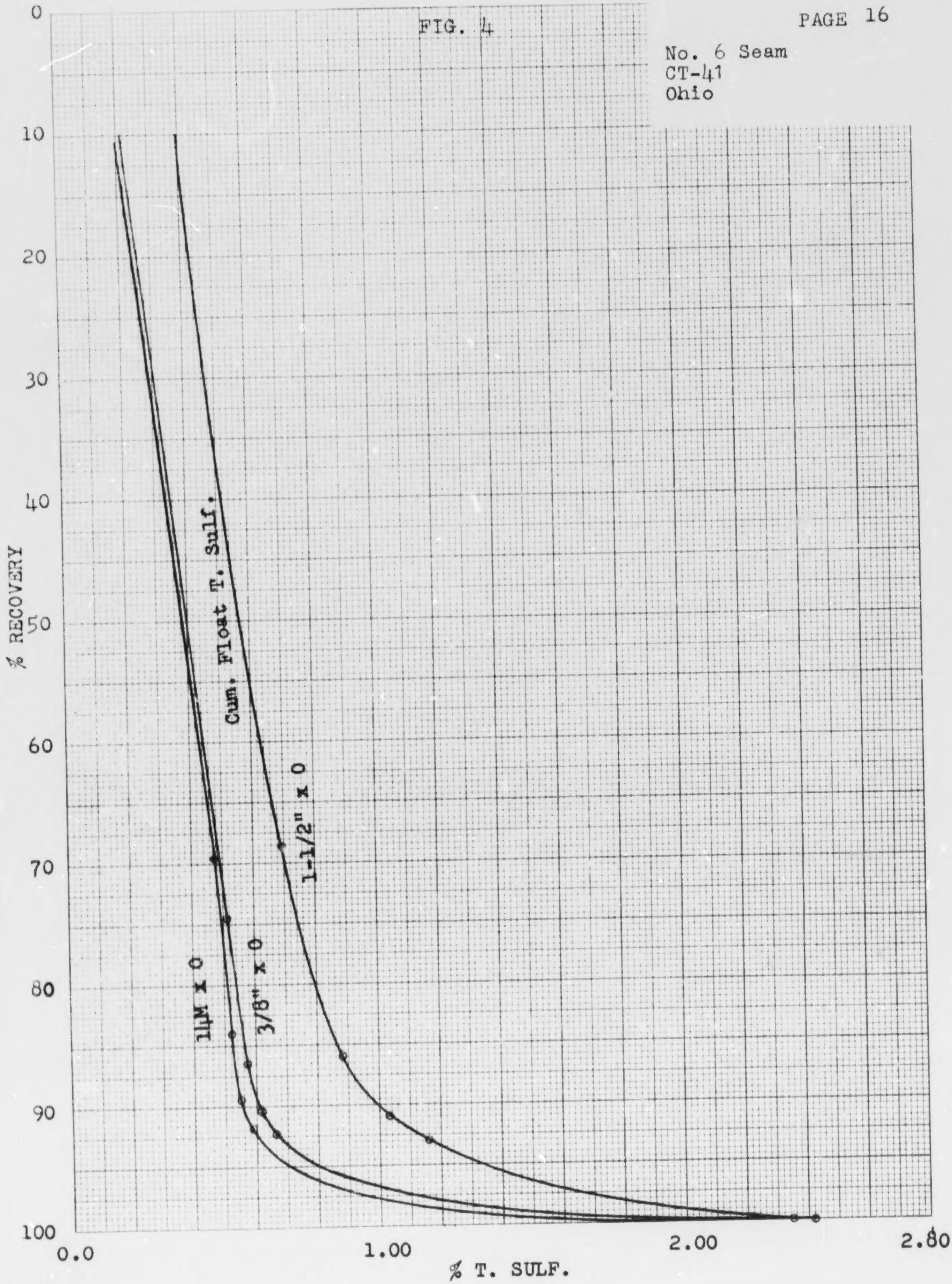


FIG. 4



No. 6 Seam
CT-41
Ohio

No. 9 Seam
CT-24
Ohio

FIG. 5

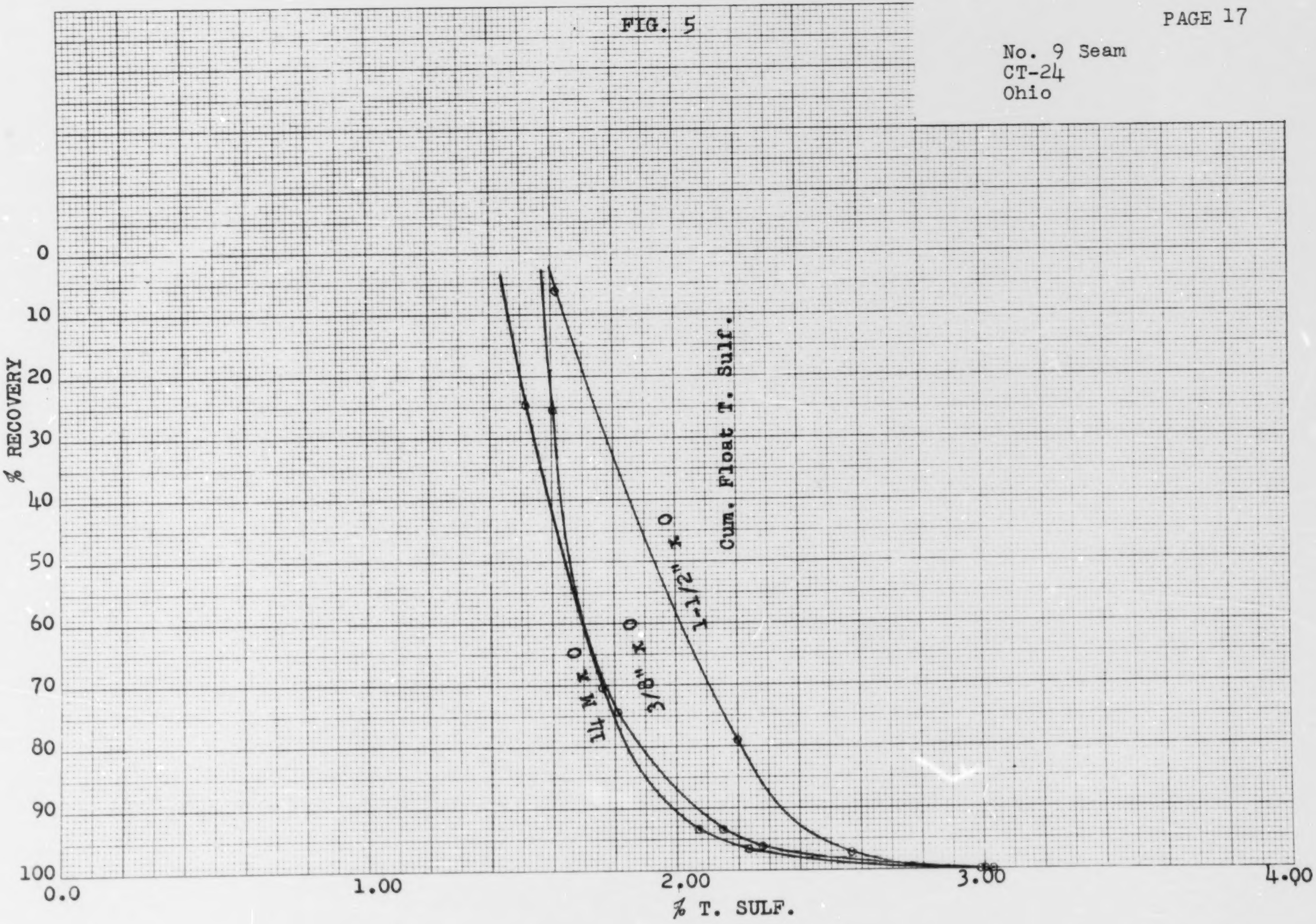
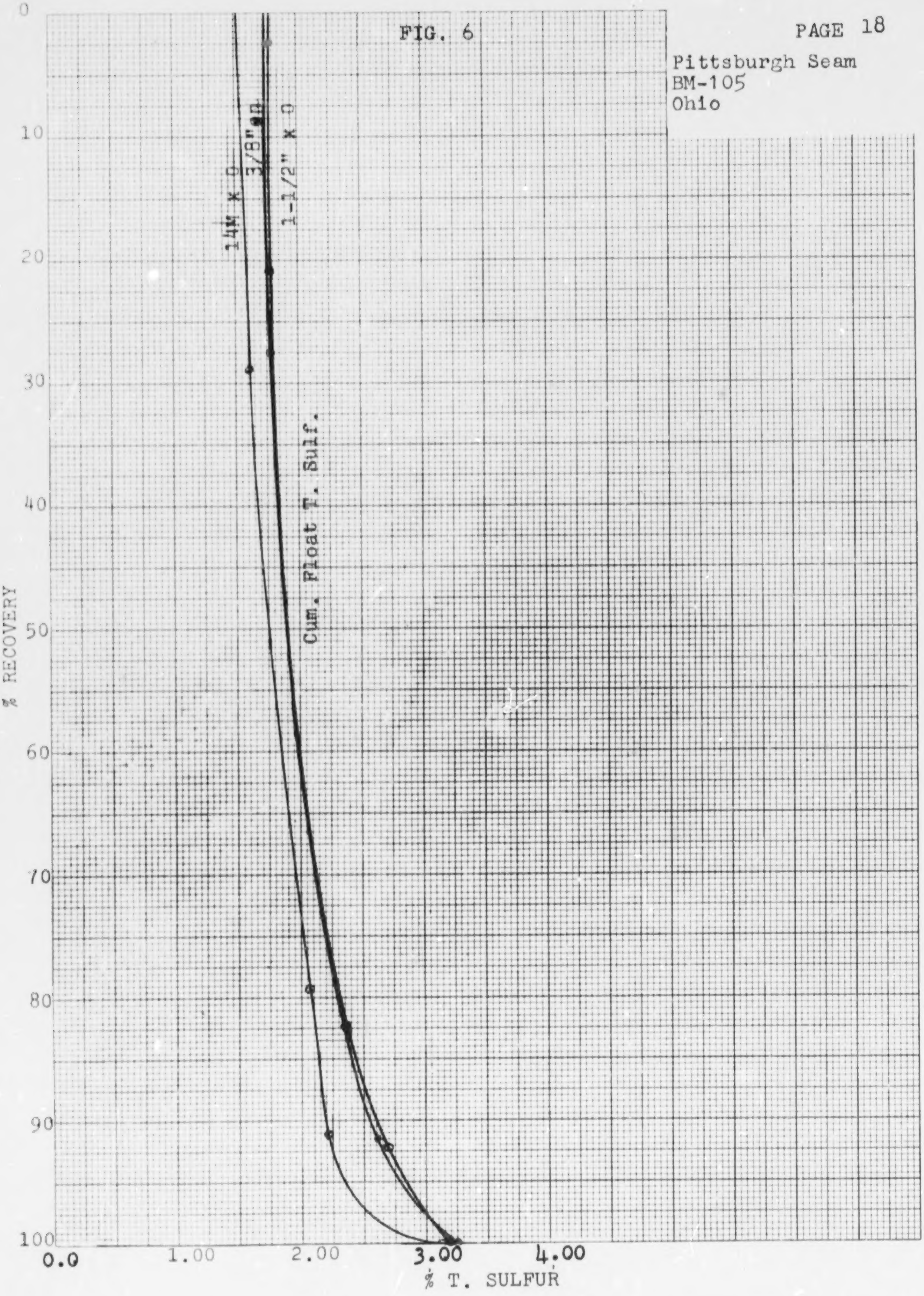


FIG. 6

Pittsburgh Seam
BM-105
Ohio



SECTION 4
STUDY OF WASHABILITY DATA

Using the subject washability data, a prototype coal preparation plant has been designed to reduce the sulfur in these various coals, when practical to do so. This broad range of washability data cover coals with a wide variety of characteristics. It was therefore necessary to design a plant which would be flexible enough to handle all types of coals coming from the various coal seams. To appreciate the complexity of washing problem from the several states involved, a few typical washability data from those supplied by HEW have been selected for the discussion outlined below.

The 3/8" x 0 size has been considered primarily because there are very few coals from which the sulfur can be reduced to an acceptable sulfur level at a satisfactory yield for the 1½" x 0 size. As would be expected, in most coals a greater sulfur reduction can be attained at 14M x 0 than at 3/8" x 0, but it would be uneconomical to crush coal to 14M x 0; washing of this size coal has not been considered unless this was the only way to achieve an acceptable sulfur level.

Figure 7 is an illustration of a 3/8" x 0 size coal (from CT-4 in Pennsylvania) with a natural cut point at about 1.70 Sp. Gr. In this case, washing would recover theoretically about 85.7% washed coal with 0.78% total sulfur. In actual washing, of course, there will be some deviation from this yield depending upon the washing efficiency of the equipment used.

Although only a few of the subject coals can be washed at the 1½" x 0 size, it is obviously much more economical to wash coal at coarser sizes than at 3/8" x 0 or 14M x 0. Coal from CT-41 in the State of Ohio, as shown in the Figure 8, could be washed at 1½" x 0 size to attain a sulfur level of less than 1.00%. At about 1.45 Sp. Gr., this size would attain a theoretical yield of 88.2% containing 0.94% sulfur.

FIG. 7

'C' Prime Seam
CT-4
Pennsylvania

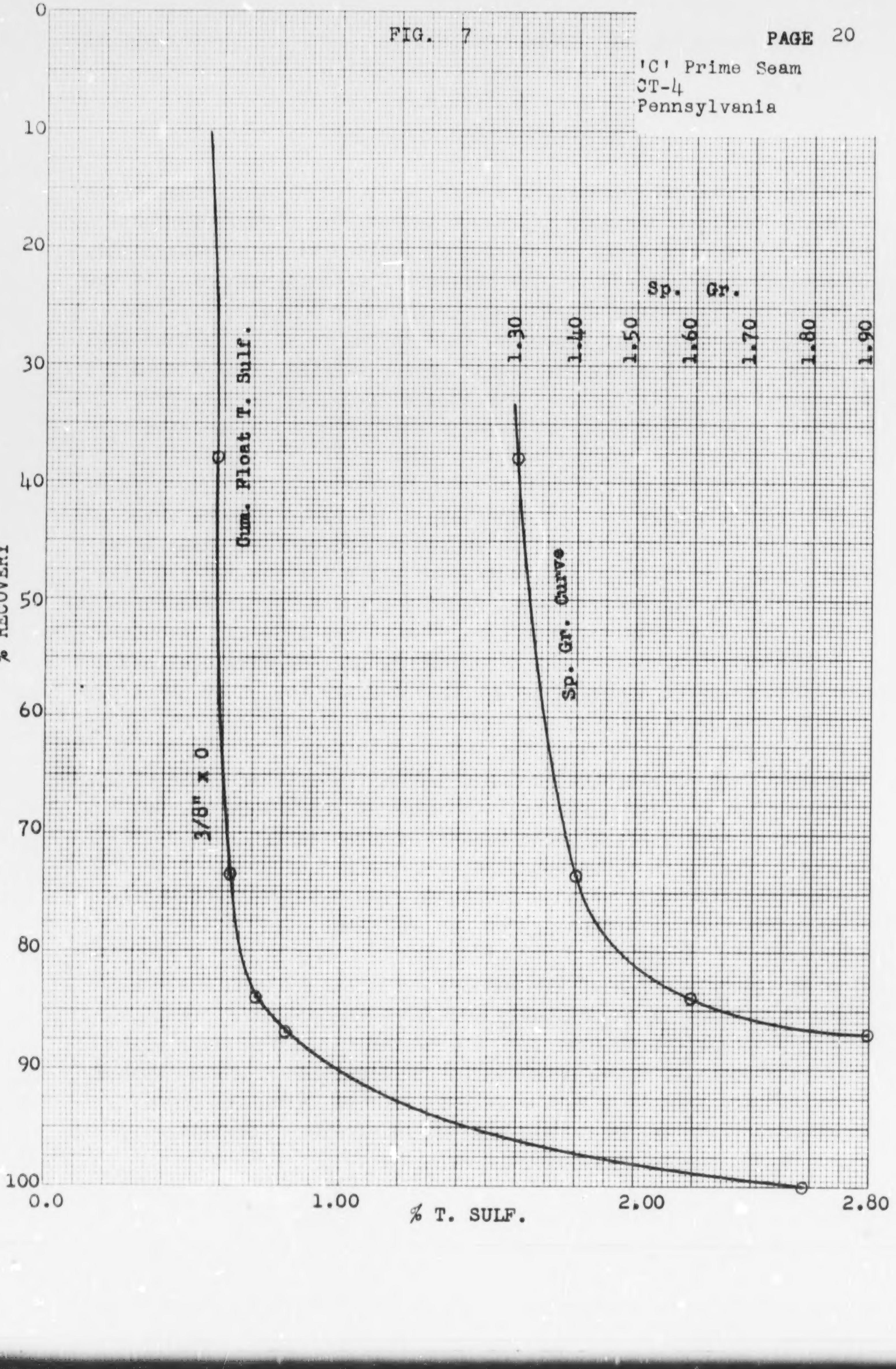
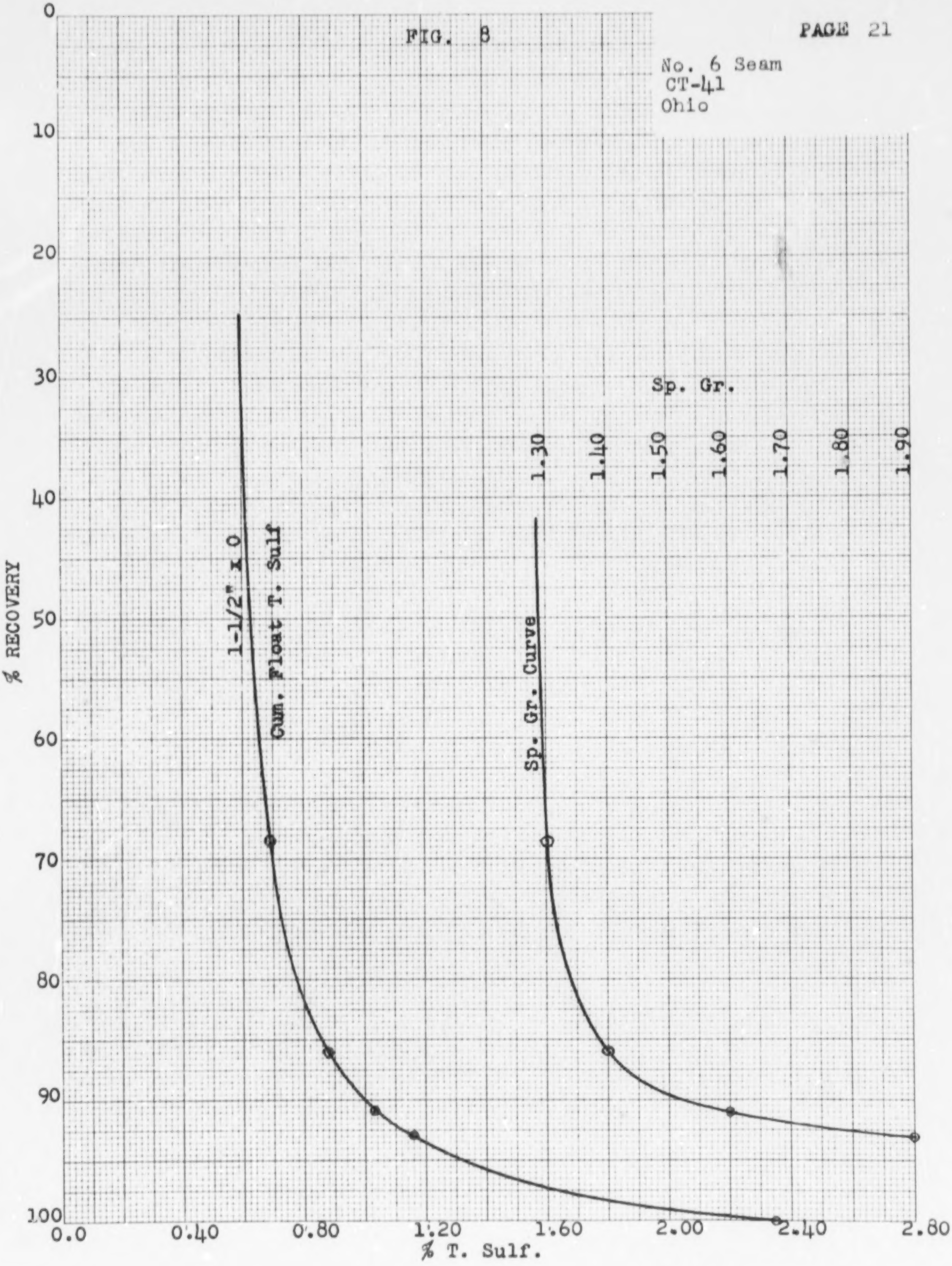


FIG. 8



No. 6 Seam
CT-41
Ohio

At the other extreme is the example of Lower Cherokee Seam from BM-31 of Iowa--shown in Figure 9. In this case, a low sulfur level can be obtained only by washing 14M x 0 size coal. At a Sp. Gr. of about 1.40 the theoretical yield would be 89.2% with an 0.94% sulfur content. At 1½" x 0 or 3/8" x 0 sizes, the sulfur content would be 1.27% and 1.09% respectively when washed at the same specific gravity of 1.40.

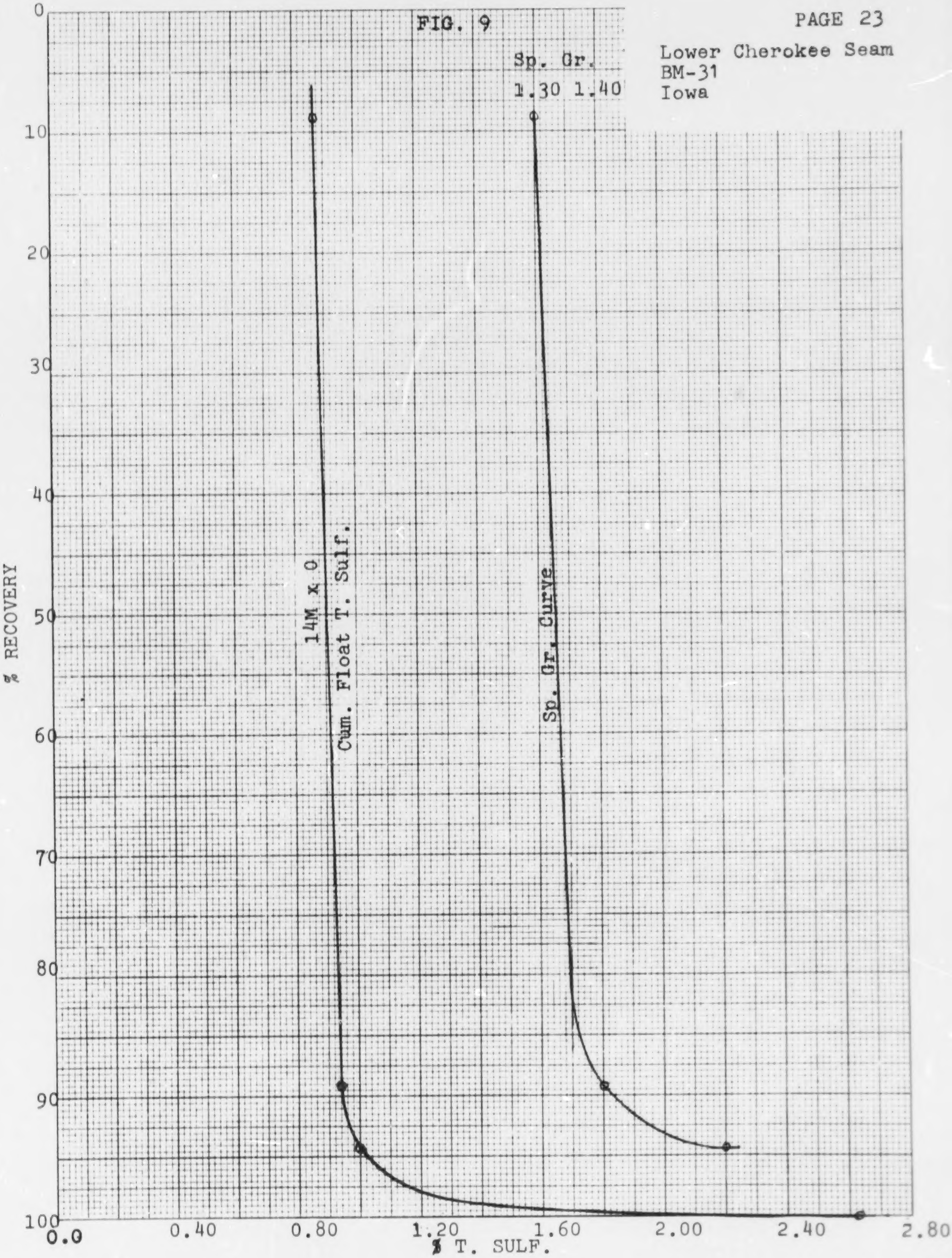
Figure 10 illustrates an example (CT-54 in Illinois) of a coal difficult to clean. Sulfur in the raw coal is 1.32% and the sulfur particles are so intimately mixed with the coal that it is not possible to reduce the sulfur content in the washed coal to 1.0% even when washing a 14M x 0 size; at 1.60 Sp. Gr. the theoretical yield of this coal would be 79.4% with 1.20% sulfur, which means that it would not be worthwhile to crush this coal to 14M x 0.

There are some coals which must be washed at a low gravity to yield a low sulfur product. Figure 11 shows an example of such a coal (BM-50 in Pennsylvania). Although sulfur in the raw coal is 2.38%, washing at about 1.35 specific gravity will theoretically yield 91.0% washed coal with only about 0.80% sulfur.

Some of the other coals from the HEW washability data should be treated at a high specific gravity; the coal from CT-21 in West Virginia should be washed at a specific gravity higher than 1.70 to get a theoretical yield of more than 90% washed coal with less than 1% sulfur. Figure 12 shows the washability curve for this coal.

Approximately one-third of all the coal for which washability data has been supplied cannot be washed to less than the highest sulfur level of 2.50% as specified by HEW. A washability curve of such a coal (from BM-55 in West Virginia) is shown in Figure 13.

FIG. 9



Lower Cherokee Seam
BM-31
Iowa

FIG. 10

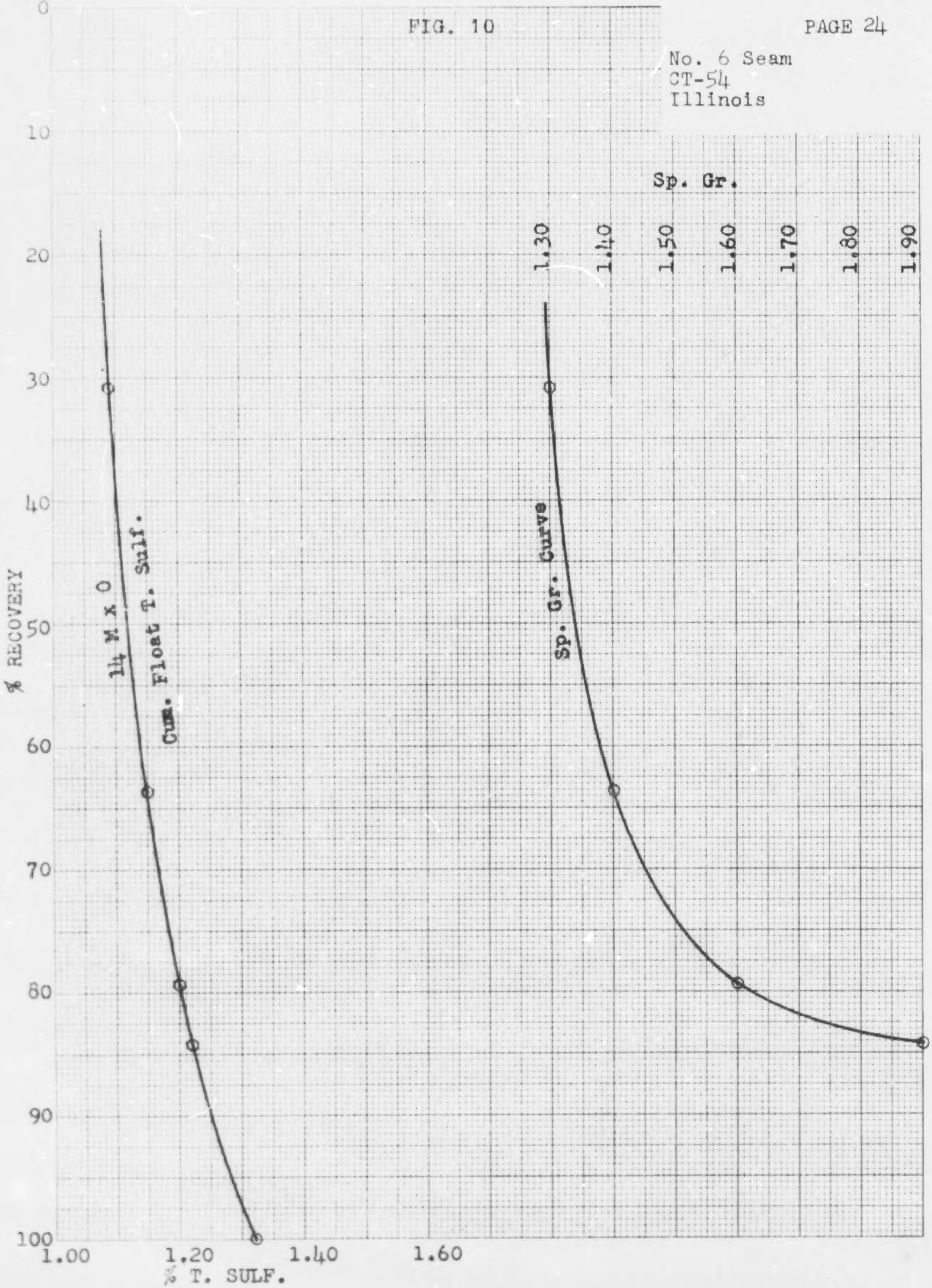

No. 6 Seam
CT-54
Illinois

FIG. 11

Brookville Seam
BM-50
Pennsylvania

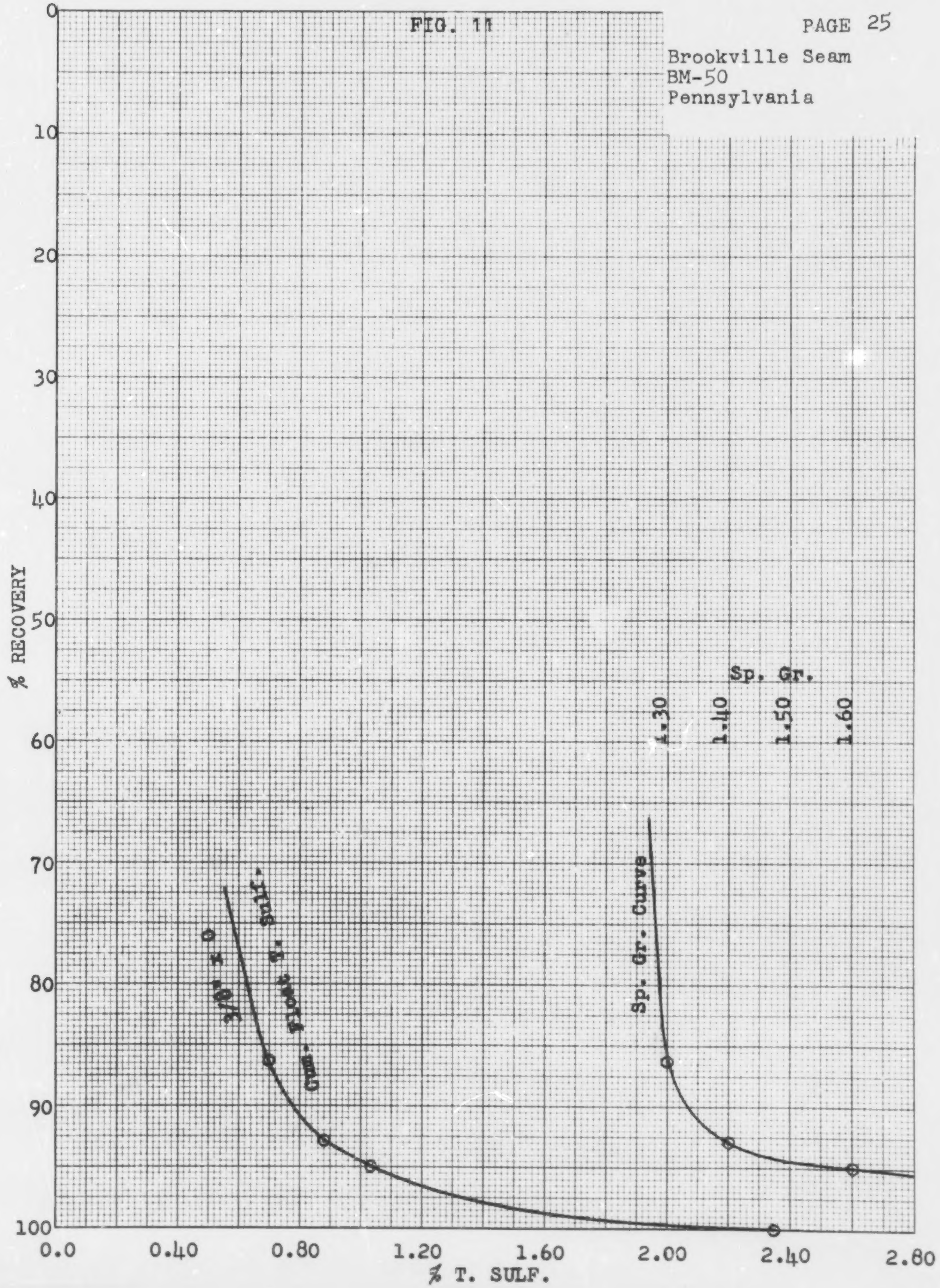
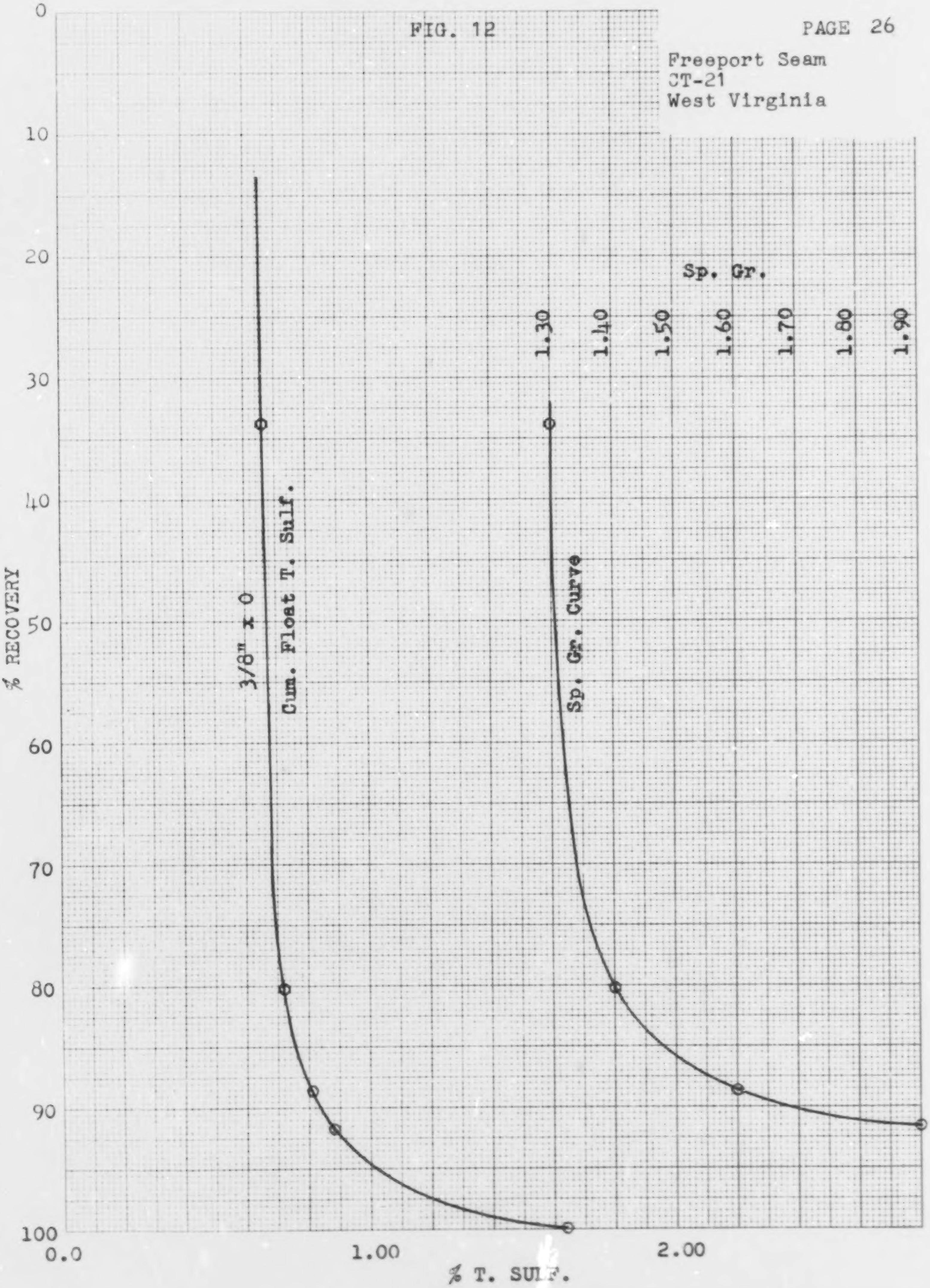


FIG. 12

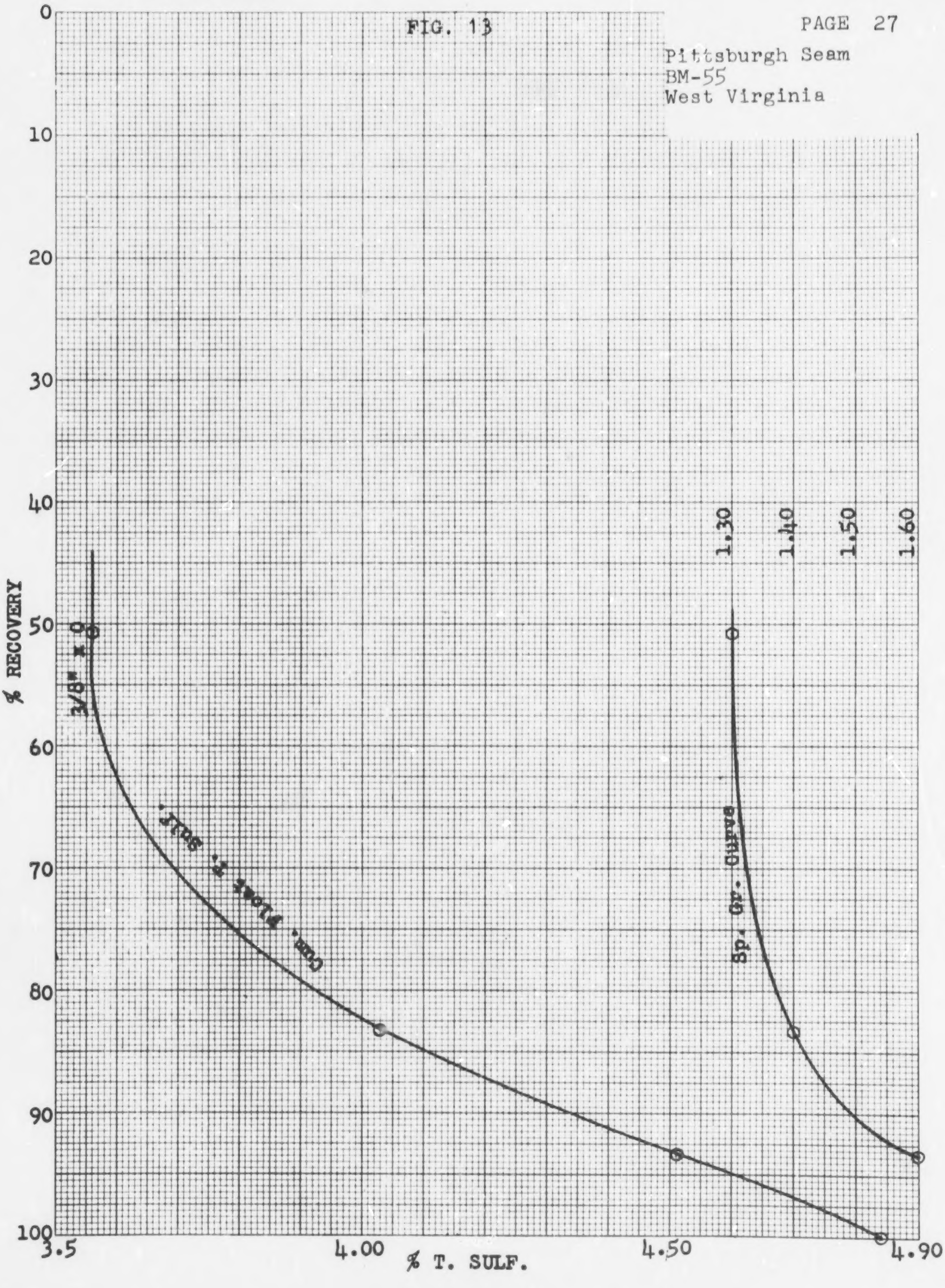
Freeport Seam
CT-21
West Virginia



NOT REPRODUCIBLE

FIG. 13

Pittsburgh Seam
BM-55
West Virginia



The above examples illustrate the wide variety of coals to be washed in the prototype plant. Keeping in view the complexity of washing so many coals with such widely varying characteristics, the prototype plant must be designed with sufficient flexibility to remove pyrite from raw coal under a wide range of conditions. The plant will, therefore, have a heavy media cycloid for treating 1-1/2" x 0 coals; or coals at a low cut point (down to 3/8" x 0 size) or coals with high near gravity material. McNally Visman Tricones will be provided to clean 3/8" x 0 and smaller size coals, or coal requiring treatment at a high specific gravity. Both coal and mineral tables will also be provided to give added flexibility.

SECTION 5

RANKING OF COAL

A method has been developed for the ranking of coals from the theoretical recovery of clean coal and total sulfur content of the clean coal from the available washability data. In arriving at this method of ranking, the following considerations were made:

(a) Theoretical recovery of clean coal.
(b) Total sulfur in the clean coal.
(c) Size of coal cleaned.

A key to the ranking of coals is given below. Table VII uses this key to show the ranking of coals for the States of Alabama, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Missouri, Ohio, Pennsylvania, Tennessee and West Virginia, from the data supplied by HEW. The rank of each coal shown in Table VII indicates the recovery range of the washed coal, total sulfur level in the washed coal, and the size of the coal washed.

The original reserves of coal seams for the States of Ohio, West Virginia, and Western Kentucky are indicated for each seam. The reserve figures shown against each mine in Table VII indicate coal reserves of the seam in the state. We were asked to obtain coal reserves for the major seams in the states of Ohio, West Virginia, and Western Kentucky, which were obtained from the Ohio State Geological Department, West Virginia State Geological Department and Tennessee Valley Authority respectively. Table VIII indicates the coal reserves for the major seams in these three states.

KEY TO RANKING

SIZE OF RAW COAL TREATED: (Denoted as numerical number)

	Number
1-1/2" x 0	1
3/8" x 0	2
14M x 0	3

RECOVERY: (Denoted as alphabet letter)

	Letter
75% to 100% Washed Coal	A
50% to 75% Washed Coal	B
0% to 50% Washed Coal	C

TOTAL SULFUR: (Denoted as subscript numerical number to an alphabet letter)

	Subscript
0% to 1.0% in Washed Coal	1
1.0% to 1.50% in Washed Coal	2
1.50% to 2.00% in Washed Coal	3
2.00% to 2.50% in Washed Coal	4
2.50% and above in Washed Coal	5

It can be seen from Table VII that the best coal is ranked as A_1 series,; i.e., $1A_1$, $2A_1$, or $3A_1$, and that the less desirable ones are in the C_5 series such as $1C_5$, $2C_5$ or $3C_5$. Rank of coal from the Table VII can be interpreted to suit the requirement of sulfur level at a given recovery. Given below is an interpretation, where the requirement for holding the sulfur level at less than 1.00% is assumed:

Good -- A_1 Series
Fair -- A_2 Series, or B_1 Series
Average -- A_3 Series, or B_2 Series, or C_1 Series
Poor -- A_4 Series, or B_3 Series, or B_4 Series or C_2 Series, or C_3 Series
Unwashable -- A_5 Series, or B_5 Series, or C_4 Series, or C_5 Series

For example, Ranking $1B_2$ of BM-91 of Alabama, the "1" means 1½" x 0 size raw coal; the "B" indicates a coal which when washed would yield a clean coal recovery of between 50% and 75%; the subscript "2" means that the total sulfur in the clean coal would be between 1.00% and 1.50%. Similarly, $2A_1$, of BM-93 in the State of Alabama signifies a 3/8" x 0 size raw coal which when washed would yield a clean coal in the range of 75% to 100% having a total sulfur content in the clean coal of less than 1.0%.

SECTION 6

PROTOTYPE PLANT DESIGN

The design of the prototype plant, the requirements for which are outlined in the Contract, requires special consideration to assure that it will suitably process a wide variety of coals from which to produce satisfactory clean coals with acceptable sulfur content. The plant should therefore be very flexible with alternate circuits and equipment choices which can be run in any combination so that it will be able to handle coals of different sizes and widely varying washability characteristics. Recovery and concentration of pyrite also requires consideration for possible future commercial utilization. In the absence of established standard methods of the recovery of pyrite from the washery refuse, alternate circuits as well as alternate equipment items are required to determine the most suitable process for any given coal. All of these points have been considered in completing the prototype plant design. The equipment and its operation are outlined briefly in the following:

(The plant flowsheet C-4527 included in the Synopsis should be used to follow this description; for convenience the unit numbers from the flowsheet are indicated in the description).

The process starts with the ROM coal crushed in a rotary breaker (8) and a crusher (4) and stored in one of the two steel silos (19), each having a capacity of 4000 tons. Eight thousand tons of raw coal storage capacity has been provided to give sufficient raw coal storage capacity to be able to run the washery for one month at an average feed rate of around 50 TPH for 22 days and one shift a day. Two separate silos are provided for the plant to draw coal from one silo while the other is being loaded with fresh coal either from the same mine which supplied the coal being washed, or from a different mine.

In the plant design, one primary 24" heavy media cycloid (38), or alternately one 20" heavy media cycloid (38), has been provided to wash 1½" x 3/8" or 1½" x 14M or 3/4" x 3/8" or 3/4" x 14M or 3/8" x 14M size coal. The 24" cycloid has an approximate capacity of 75 TPH size coal, whereas 20" cycloid should be capable of washing 50 TPH and can be used to treat 1½" x 0 coals. The alternate of using a 20" heavy media cycloid will give the plant the added flexibility needed for the wide range of operating requirements anticipated. This design will be such that a smaller heavy media cycloid could also be substituted if this were found to be desirable.

Although the plant is designed for an average capacity of 50 TPH, the raw coal crusher (28), conveyor belts (26), screens (32,43 & 69), etc., are designed with an excess capacity to increase the load in the heavy media cycloid. The raw coal scalping screen (32) will have interchangeable screens for 14M or 3/8". 14M x 0 or 3/8" x 0 size coal from the scalping screen goes to the 8" primary McNally Visman Tricones (78) for washing.

A crusher (72) has been provided after the heavy media cycloid sink screen (69) to crush the refuse for liberating the interlocked pyrite particles to permit further washing in the McNally Visman Tricones (78 & 115). The crushed refuse from the heavy media cycloid (38) or the raw coal from the raw coal scalping screen (32) is washed by eight 8" primary McNally Visman Tricones (78) to recover low sulfur coal.

High sulfur refuse from the primary McNally Visman Tricones (78) can be washed in the 8" secondary McNally Visman Tricones (115) or in sequence through the secondary McNally Visman Tricones and the coal tables (119). A Deister coal table (119) has been provided to determine the feasibility as well as efficiency of recovery of low sulfur coal from pyrite rich refuse by washing either or both in a tricone and/or in a coal table. Refuse from the secondary McNally Visman Tricones (115) can also be fed to two ore tables (123) to treat the heavier pyrite/refuse fraction.

Tailings from the magnetite separator (60) and the minus 1/2mm fraction from the classifying cyclone (83) underflow are processed in the flotation cells (94) to recover low sulfur coal from the gangue material. Flotation cells are provided in the plant to determine the feasibility as well as efficiency of recovery of low sulfur coal from pulp containing pyrite and coal. In case the pulp is not required for further processing, the flotation cells can be by-passed and pumped to the waste pond through the tailings sump (101) and the settling cone (128).

The flotation concentrate, or coal, if found low in sulfur, will be filtered (97) and mixed with the coarse washed coal and conveyed to loading. If the coal concentrate from the flotation cell is found high in sulfur and not worth recovery, the filter will be by-passed and the concentrate diverted to the waste pond.

Proper reagents to activate coal selectively and depress pyrite along with other gangue materials present in the coal slurry feed to the flotation cell have not yet been developed for all different types of coals. Work is being done in this field. The prototype plant will give an excellent opportunity to carry out tests with the various types of coals selected for processing; thus it may be possible in the operation of this plant to find a suitable activating agent for selective flotation of coal. This would not only provide valuable information for the recovery of low sulfur coal and pyrite, but would also improve upon present techniques in the recovery of low sulfur coal.

Adequate arrangements for the recovery of the magnetite from the dilute medium have been provided. The dilute medium will be thickened in a thickener (54) and the magnetite recovered by a double drum magnetite separator (60) for reuse in the system.

Clarified water from the thickener and settling cone will be used in the plant.

As the washed coal is expected to have a high surface moisture, we recommend that consideration be given to the installation of a fluid bed type thermal dryer to dry the fine coal.

Installation of a dryer for this fine coal will generate valuable information on:

(a) Fuel consumption versus dust loss when operating with various velocities.
(b) Size analysis of the dust lost to the atmosphere.
(c) Size analysis from the dryer to the primary dust collector .
(d) Size analysis of the product over the grate.
(e) Size analysis of the product from the primary cyclone dust collector.
(f) Selection of dust collecting equipment required to meet the dust emission code of various states.
(g) Concentration of sulfur in the scrubber effluent.
(h) Loss of solids with the scrubber effluent.
(i) Change in sulfur content of the dried product versus the dryer feed.

The above information will be valuable to meet the anti-pollution requirement in designing a full-scale plant.

PART IV

SAMPLING & TESTING

1. Detail on Sampling and Testing:

Adequate testing arrangements have been provided in the plant to evaluate each coal selected for processing, and to evaluate the performance of individual equipment as well as the whole plant. The purpose of testing program is:

(a) To evaluate performances of each major piece of equipment used in the plant.

(b) To evaluate each coal selected for processing.

(c) To evaluate overall performance of the plant for cost analysis.

(d) To make comprehensive plant studies including material balances, ash, total sulfur and pyritic sulfur content for each coal.

In order to provide adequate test data, the plant will be provided with twenty-nine (29) sampling points, twenty-seven (27) automatic solid and pulp samplers and two (2) manual sampling arrangements.

Raw Coal Tests: Approximately 8000 tons of each test coal will be delivered to the plant. As the first 4000 tons is crushed to 1-1/2" x 0, a raw coal sample will be collected during one to two weeks prior to the start of each test.

This sample will be collected by an automatic sampler and will be based on sampling lots at 2800 tons in seven (7) hours and 400 TPH feed. Sampler will take nine (9) cuts per hour at 55.6 pounds per cut for a total sample of 500 pounds per hour. Samples will be sent to two bins set to receive alternate cuts for a total of 250 pounds per hour to each bin.

(The material reporting to the rock bin from the rotary breaker will be weighed, hand sampled, and analyzed for percent ash, percent sulfur and percent pyritic sulfur.)

This will satisfy all conditions for ASTM D2234-65T on Mechanical sampling of coal and D492048 sampling coals classified according to ash content. It will also provide the proper gross sample to make the washability study from which plant settings can be made.

The primary gross sample will be screened to produce the following sizes:

1½ " x 3/4"
3/4" x 3/8"
3/8" x 14 Mesh
14 M x 28 Mesh
28 M x 48 Mesh
48 M x 0

Float and sink separations will be run on each size fraction at the following gravities: 1.30, 1.35, 1.40, 1.50, 1.60, 1.90, 2.20, 2.50 and 2.80. The refuse will be visually examined to see if heavier gravities are required.

Dry ash, total sulfur and pyritic sulfur will be run on each size gravity fraction and composities calculated for each size which might be used as feed to a piece of equipment in the cleaning plant:

1½ " x 3/8"
3/8" x 14 Mesh
1½ " x 14 Mesh
3/8" x 0
14 M x 0

The laboratory will be equipped with sufficient equipment and personnel to provide this data within the one week period before the coal is to be tested.

Test Period Samples: From the data supplied, operating personnel can anticipate an optimum setting for each piece of equipment. As a new coal is first fed to the plant, grab samples will be collected to check the specific gravity of operation. When the various circuits are set to the operators' satisfaction, daily runs can be started to determine optimum plant conditions to produce the maximum sulfur removal from the coal. In some cases it is likely that it will be necessary to check more than one set of alternative conditions to determine the point of optimum sulfur reduction.

Specifications for Plant Samples:

Top Size	No. of Increments	Wt. of Increments	Gross Sample Wt.
1-1/2" (a)	70 (c)	6-10 Pounds	420-700#
3/8" (b)	70 (c)	2-4 Pounds	140-280#
14 Mesh	70 (c)	1-2 Pounds	70-140#

* When sampling primarily liquids instead of solids, one to two pints per increment shall be collected.

(a) 6-10 pound increments will be collected because ASTM specifies a minimum of 6 pounds.

(b) 2-4 pound increments will be collected because ASTM specifies a minimum of 2 pounds.

(c) 70 increments will be collected because, although ASTM specifies a minimum of 35 increments for any analysis, 70 are required to obtain sufficient material for screen tests.

Schedule: Normally for the circuit being tested there will be one run made per day, broken into three segments. The morning (A.M.) samples will consist of a 2 to 2-1/2 hour run and will be removed from the samplers by 12:00 noon. This will require preliminary morning work to be completed and the plant stabilized no later than 9:30 A.M. (During the plant adjustment period all automatic samplers will be inactivated except when the plant operator requests a "grab" sample for Float & Sink checks on the adjustment of any piece of equipment.)

The A.M. samples will be screened and floated to determine the approximate washing gravity of the products from each cleaning unit referenced to the raw coal data.

On all samples from morning test runs, the feed and product samples will be screened, where sizes are available, at 3/4", 3/8", 14, 28, 48, 100, 150 and 200 mesh. All size fractions of feed materials and dewatered clean and refuse products applicable to the circuit or circuits being tested will be subjected to float and sink separations two gravities above and below the anticipated gravity of separation.

The afternoon (P.M.) samples will be used only for material balance of the plant in terms of percent ash, sulfur and pyritic sulfur.

Laboratory flotation tests will be made on all feeds to the flotation cells, using reagents to be selected at a later date. All size and gravity fractions as well as flotation fractions will be analyzed for percent ash, total sulfur and pyritic sulfur.

All test work or daily runs will be completed no later than 5:00 A.M. the following day, at which time the raw data will be fed into a computer for processing. During separate circuit testing the completed report for the previous day's run will be available for operating personnel by 7:00 A.M.

Procedures for Processing Samples: The various automatic samplers have been numbered on the plant flow sheet for the sake of orderly planning and discussion of the treatment of individual samples. A coded system will relate samples to samplers, coal being processed, tests run, size of product and date of test. It is anticipated that drying of samples will be done by microwave techniques, which is a process for continuous and rapid drying of wet samples without induced heat.

Minimum Test Schedule: (One run for each operating condition)

1. Heavy Media Cycloid Circuit:

    Available Feed: 1½" x 3/8"
    (Raw Coal) 1½" x 14 Mesh
    3/4" x 3/8"
    3/4" x 14 Mesh
    3/8" x 14 Mesh

    Normal separating gravity settings: 1.35 to 1.80

NOTE: One low gravity and possibly one high gravity separation will be required for each size of feed tested. Raw coal data may indicate that testing of all available sizes will not be necessary.

2. Tricone Circuits:

   Available Feed: 3/8" top size raw coal

   14M x 0 crushed cycloid refuse

   Normal separating gravity settings: 1.35 to 2.50

NOTE: A minimum of one run must be made with each type of feed to the circuit.

3. Tables:

   Available Feed: Secondary Tricone Rejects

   Primary Tricone Rejects

NOTE: A minimum of one run is necessary for each feed to the table.

4. Flotation Circuit:

   Available Feed: 1/2mm x 0 underflow from the various circuits.

NOTE: A minimum of one run will likely be made for each coal delivered to the plant.

5. Total Plant Circuit:

   After the various plant circuits are set for their best performance in sulfur reduction, at least three prolonged runs will be made with all sampling stations of all circuits in use so that a complete plant evaluation can be made of each run. In addition to the sizing-gravity separations, and ash, sulfur and pyritic analyses, actual separating gravities and efficiencies of separation may be determined together with plant material balances.

   The plant feed and final cleaned coal products will have a complete analysis made as shown on the attached CT&E form to determine how removal of various components is likely to alter burning and slagging characteristics of the final product. A minimum of one run must be made for the total plant after all circuits have been set at optimum conditions.

NOTE: This means that for every coal tested there should be a minimum of four test runs made at a single feed rate chosen for each circuit in the plant. On the other hand, triplicate runs could be made for each change in type of feed or setting of equipment if confirming data is required for statistical reliability. It would thus be possible to make more than 100 runs on each type of coal delivered to the plant without exhausting the technological capabilities of the plant or the technical reasons for making the test runs.

Due to the volume of samples scheduled to be processed, it is the intention routinely to sample makeup water and plant effluent as well as any pond water or streams which might be affected by the plant operation, then to process such samples in one of CT&E's Laboratories. Comprehensive analysis (See page 41) of feed and products will also be processed by one of CT&E's Laboratories normally handling this type of work. The cost of these additional analyses would be at standard CT&E prices.

A complete test schedule for testing a candidate coal every month is given in Page 43.

If deemed advisable, provision can be made at additional cost to include the following additional types of tests:

1. Abrasiveness test of raw and clean coal products to determine benefits of removing pyrite.
2. Thermo-gravimetric and differential thermal analysis to determine ignition temperatures and profiles of raw and clean coal products.
3. Neutron activation analysis for trace elements of raw and clean coal ash contents obtained by low temperature ashing techniques. These data could be the basis for correlation studies of particulate air pollution and high temperature reactions in combustion gases.

COMMERCIAL TESTING & ENGINEERING CO.
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SINCE 1908

MAIL ADDRESS
16130 VAN DRUNEN ROAD
SOUTH HOLLAND, ILLINOIS
(CHICAGO) 60473
PHONE 312 264-1173

Kind of sample reported to us

Sample identification by

Sample taken at

Sample taken by

Date sampled

Analysis report no.

PROXIMATE ANALYSIS	As received	Dry basis
% Moisture		
% Ash		
% Volatile		
% Fixed Carbon		
Btu		
% Sulfur		
% Alk. as Na_2O		

SULFUR FORMS	As received	Dry basis
% Pyritic Sulfur		
% Sulfate Sulfur		
% Organic Sulfur		
% Total Sulfur		

WATER SOLUBLE ALKALIES
% Na_2O =
% K_2O =

ULTIMATE ANALYSIS	% Weight As received	Dry basis
Moisture		
Carbon		
Hydrogen		
Nitrogen		
Chlorine		
Sulfur		
Ash		
Oxygen (diff)		

MINERAL ANALYSIS	% Wt. Ignited Basis
Phos. pentoxide, P_2O_5	
Silica, SiO_2	
Ferric oxide, Fe_2O_3	
Alumina, Al_2O_3	
Titania, TiO_2	
Lime, CaO	
Magnesia, MgO	
Sulfur trioxide, SO_3	
Potassium oxide, K_2O	
Sodium oxide, Na_2O	
Undetermined	

FUSION TEMPERATURE OF ASH	Reducing	Oxidizing
Initial Deformation	°F	°F
Softening (H = W)	°F	°F
Softening (H = ½W)	°F	°F
Fluid	°F	°F

H is Cone Height
W is Cone Width

SILICA VALUE =
T250 = °F

% EQUILIBRIUM MOISTURE =
HARDGROVE GRINDABILITY INDEX =
FREE SWELLING INDEX =

ESTIMATED VISCOSITY
at Critical Viscosity Temperature of °F = Poises

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Charter Member

I. O. FOSTER, Manager, Midwest Division

2. Testing Program:

The testing program has been designed to permit comprehensive coverage of all sampling stations or only a few stations as may be dictated by coals and circuits being tested. Sufficient personnel and equipment will be provided to perform all necessary tests on a day's run prior to the start of the next day's run. Both equipment and personnel are excessive if only one circuit is being tested. However, it must be recognized that in addition to the daily tests, a washability is required prior to each program for each coal. Furthermore, at the end of each month there will be one or more comprehensive plant studies including material balances and ash, sulfur, and pyritic sulfur balances. This work will require substantial personnel and will have to be performed at hours when it will not interfere with the routine tests.

The laboratory staff will in addition to maintaining the plant testing program regularly collect samples of water for analysis comparisons of plant make-up water as well as effluent water. All water coming onto the property and leaving the property will be checked.

A monthly test schedule is given in Page 43.

MONTHLY TEST SCHEDULE

Circuit	Available Feed	Separating Gravities	Minimum Test Runs	Samplers Sampled	Optimum Schedule
H. M. Cycloid	1-1/2 x 3/8			2, 3, 4	
	1-1/2 x 14		1 Low Gravity	5, 6, 7	1st Day
	3/4 x 3/8	1.35-1.80	1 High Gravity	8, 9, 10	2nd Day
	3/4 x 14			11, 12, 13	
	3/8 x 14				
Tricone	3/8" Top Size	1.35-2.50	1 Low	14, 15, 16, 17	3rd Day
	Crushed Cycloid		Gravity		
	Refuse			18, 19, 20, 21,	
				22, 28	
Tables	Prim. Tricone Reject	1.45-2.80	1 Run	23, 24 & Mids.	
				where available	4th Day
	Sec. Tricone				
	Reject		Three Products		
Flotation	1/2mm x 0				
	Underflows		1 Run	25, 26, 27	5th Day
Complete Plant	2nd, 3rd, and 4th Weeks			All Samples	

NOTE: Complete plant tests of difficult coals might be delayed until after the 2nd or 3rd week due to additional runs required on some circuits to delineate optional flow patterns.

3. Storage of Data:

During the operation of the pilot plant for three years, valuable information on the reduction of sulfur for various coals will be generated. A substantial amount of test and operational data will also be available on the plant as a system as well as on the various individual regular items of equipment. This data needs to be preserved in proper order for future use.

Besides this, these data must be properly catalogued and stored in a manner which will assure ready access for current use during the test program. For these reasons, it has been considered wise to include a microfilming arrangement together with an automatic storage and retrieval system as a part of the office equipment provided for the laboratory and test equipment.

Detail on the data handling and storing is given below:

(a) Data Collection

Standard Register Company Key Punches in plant and lab. where data is generated.

Key punches 80 column Hollerith preprinted cards with soft copy snap-out for checking against print-out of items punched.

(b) Data Input Transmission

General Electric terminals in office at plant site connected via telephone circuits (cable, micro-wave, or telestar) to off-site G.E. 600 computers for remote batch and/or time-sharing service available 24 hours as needed.

Back up will be provided by two terminals on site with access to alternate computers via transmission of duplicate punched tape programs kept for emergency in office at plant site. Main programs will be stored in off site computers.

One terminal will be high speed Model 105 Remote terminal equipped with Card Reader with capacity of reading 600 cards per minute with input data being compiled and buffered for transmission to off site computers via two channel voice grade telephone lines at rate of 125 cards per minute or via four channel lines at rate of 250 cards per minute.

NOTE:

Four channel lines can receive and send at the same time whereas two channel lines can only send when not receiving or receive when not sending. In other words, four channel lines are simultaneous in-out lines.
The second terminal will be a G.E. Termi Net 300 that can send or receive at 30 character per seconds, either from punched paper tape or punched cards. Although a much slower terminal than the Model 105, it is twice as fast as the 15 character per second terminal usually used by IBM for time sharing and three times as fast as the 10 character per second Model 35 teletype terminal.
The Termi Net 300 terminal will be used to process data through-out the day, and the Model 105 will be used to give a high speed completion of calculation in the last two hours (5 AM-7AM) before the next day's operation begin.

(c) Data Computation

Two systems will be available for handling input data:
Series 600 3D Resource Remote Batch for handling data from either terminal.
Series 600 Mark II Time Sharing for handling data from the Termi Net 300 terminal.
Choice of Basic or Fortran languages are available for either system, and programs will be written in the most efficient language for specific programs. Probably some programs will be in Basic and other in Fortran.

(d) Data Output

Each terminal will be equipped with fan-fold ratchet feed paper for hard copy output, which will be formatted for Xerox printing on preprinted report forms. Xerox Models 2400 or 3600 will be used for this printing, after the computer output has been checked for accuracy.

The printers will handle 118 characters per line minimum, 136 characters per line maximum, two lines per second on the Model 105 and four seconds per line on the Termi Net 300.

(e) Data Storage

Xerox printed hard copy will be micro-filmed, using an Eastman Kodak Model RD 3 Micro-filmer with capacity of 200 lines per second.

Processing of the film will be handled by Kodak Model DVR Prostar Processor, and viewing on Kodak Model PE 1A Reader-Printer (30 seconds per page).

A 100 foot roll of 16 mm film will hold 3000 pages of data or about one weeks' output at maximum testing rate. Viewing can be accomplished when required at a rate of eight feet per second.

Film storage will be in coded magazine (closed container) filed in metal cabinets designed for this purpose-800 rolls per cabinet.

(f) Data Retrieval

General Electric Closed Circuit Video system will be used to provide access from the plant control room to needed data stored on microfilm in the office. Voice communication between plant and office will be provided by telephone cabled inter-com system.

The video system will consist of an 875 line Model 4TE21A2AA GE camera (in the office) cabled to a GE Model Conrak C2F17 875 line Monitor with video amplifier (in the plant control room).

This system will prevent unauthorized access to data stored in the office since hard copies of data can be held to a minimum and video output will not be permanent.

A Xerox copyflow can also be provided, if necessary, for high speed print-out of microfilm rolls (20 feet per minute). This would be an additional cost of $800 - $1000 per month to the proposal.

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PART V

CAPITAL & OPERATING COSTS

SECTION 1

SITE

The location of the prototype plant has to be selected based upon the following influencing factors:

a. Operational expenses.
b. Location of coals to be studied.
c. Outlet for washed coal.
d. Facilities for refuse storage.
e. Availability of coal handling facilities.
f. Availability of necessary services.
g. Availability of testing facilities.
h. Availability of manpower.
i. Availability of railway facilities.

Taking all these factors into account, a site near Terre Haute, Indiana has been selected. The site belongs to Peabody Coal Company and has an idle coal preparation plant available, the facilities of which can be made available for installation of the necessary pilot plant equipment. The site has all of the facilities mentioned above.

This site is centrally located taking into account the fact that coal will be delivered from the following different states:

Arkansas
Colorado
Illinois
Indiana
Iowa
Kansas
Kentucky
Missouri
Ohio
Oklahoma
Pennsylvania
West Virginia

The plant would be located within 15 miles of Terre Haute, Indiana with a suitable access road making it convenient to visit the plant. Besides, it has all the facilities such as ground space for refuse disposal or storage, fresh water pond, waste disposal pond, utility services, etc., which are required for a modern coal preparation plant. The plant site is more than adequate to accommodate a large roasting plant and a companion chemical plant for processing the recovered pyrite from the washery refuse.

The proposed pilot plant will have its own laboratory facilities. Besides its own facilities, the plant will also have access to the well equipped testing laboratory of Commercial Testing and Engineering Company at Terre Haute, Indiana.

There is rail-head facility available in the plant for bringing raw coal to the plant as well as for transporting washed coal from the plant. The rail track will have facility to accommodate up to 40 raw coal cars at one time. Although the existing plant is out of commission, the building, hoppers, settling cone and some of the equipment are still available in good condition for use in the proposed pilot plant.

The depreciation cost of the plant and laboratory indicated in page 58 includes our estimated cost of disposal of the complete facility.

SECTION 2

COST ANALYSIS

A. ESTIMATED CAPITAL AND THREE-YEAR OPERATING COSTS FOR THE LABORATORY

The recommended pilot plant has been designed with a laboratory with adequate sampling and testing facilities to assess coals with a broad range of characteristics as well as the efficiency of the plant and its principal items of process equipment. Since the sampling and testing facilities provided in the laboratory have been explained earlier, they will not be detailed here but a summary of the equipment investment and the laboratory operating costs are given.

The following documents, prepared by the Commercial Testing and Engineering Company are used for reference:

1. Sampling - Analysis Matrix
2. List of Equipment
3. Estimated Operating Cost
4. Estimated Start-Up Cost
5. Start-Up Supplies

Since in the event the proposed plant is to be constructed and put into operation and since it is expected that The McNally Pittsburg Manufacturing Corporation will be the prime contractor for the plant construction and operation of the project, a nominal overhead and profit has been added to the costs estimated by C.T. & E. as explained below:

(a) The total estimated investment for the equipment shown under the Sampling - Analysis Matrix is $510,605.05. To this an overhead and profit has been added at the rate of five percent (5%) plus five percent (5%) respectively, making a total of $564,353.00. Add $513,838 for building, electrical wiring, erection of laboratory equipment, etc., making a total $1,078,191. The price of the equipment has been included at the current prices quoted by the suppliers.

(b) It is estimated that the total laboratory personnel requirement will be 62 for the various operations per the detail shown under Sampling - Matrix. The estimated wages of the laboratory personnel have been based upon the prevalent rates of the U.M.W. in the State of Indiana.

(c) The C.T. & E. start-up cost is estimated to be $798,660.00 and on adding overhead and profit at the rate of five percent (5%) and eight percent (8%) respectively, the total cost comes to $911,514.00. It is estimated that the starting-up and debugging of the plant will require four (4) to six (6) months.

(d) The total annual operating cost of the laboratory is estimated to be $1,548,560.00. This does not include the cost of utilities such as water, gas and electricity. The estimated annual cost for the utilities is $37,340.00. Therefore the estimated total annual operation cost including utilities comes to $1,585,900.00. Adding overhead and profit at the rate of five percent (5%) and eight percent (8%) brings the estimated total up to $1,810,000.00.

Estimated cost of running the laboratory per ton of raw coal washed:

I. It is envisaged that at the rate of 50 tons of raw coal per hour, one shift a day and 22 days a month, 8000 tons of coal will be washed per month, which means 96,000 tons per year. Considering a six months start-up period of the plant at a 50% operating rate and at a full 50 TPH for the three years, the total raw coal processed in 3-1/2 years would be 96,000 x 1/4 + 96,000 x 3

= 312,000 tons

II. Depreciation of the laboratory equipment at the end of 3-1/2 years is estimated to be 90%; that is,

$ 1,078,191 x 0.90 = $970,372

Final depreciated value of the laboratory is
$1,078,191 - $970,372 = $107,819

III. Laboratory start-up cost = $ 911,514.00

IV. Laboratory operating cost for three years -
$1,810,000.00 x 3 = $5,430,000.00

V. The estimated insurance on the laboratory equipment of $564,353 during the erection period of 1 year at the rate of 27.2¢ by $100 would be $1540.00

The estimated insurance on the laboratory equipment of $564,353 during 3½ years operation, including start-up, at the rate of 50.7¢ by $100 would be $10,000.00

The estimated total insurance for the period of
4½ years - $11,540.00.

VI.

The estimated equipment investment -	$1,078,191.00
Start-up Cost -	$ 911,514.00
Operating Cost for 3 years -	$5,430,000.00
Insurance for 4½ years -	$ 11,540.00
	$7,431,245.00
Less depreciated value of the plant (10% of the investment)	$ 107,819.00
	$7,323,426.00

VII. The running cost of the laboratory per ton of raw coal washed:

$7,323,426/312,000

= $23.5

B. ESTIMATED CAPITAL AND THREE-YEAR OPERATING COSTS FOR THE PROTOTYPE PLANT

1. Capital Cost

The estimated cost break-down of the recommended prototype plant is given below:

(a)	Cost of plant and equipment -	$ 1,649,400
(b)	Cost of erection -	$ 508,600
	Total Capital Cost of the plant -	$ 2,158.000

2. Operating Cost

I. The cost analysis of the operation of the prototype plant recommended depends on the following criteria. The analysis given below must be considered no better than a rough estimate.

Average price of R.O.M. Coal	-$4.50/ton
Selling price of pyrite (with 40% sulfur)	-$4.50/ton
Selling price of washed coal with	
less than 1% sulfur	-$6.45/ton
1.0-1.5% sulfur	-$5.95/ton
1.5-2.0% sufur	-$5.70/ton
2.0-2.5% sulfur	-$5.25/ton
Freight for transporting raw coal from:	
Charleston, W. Virginia	-$5.19/ton
Johnstown, Penn.	-$4.82/ton
Hennreatta, Oklahoma	-$16.40/ton
Birmingham, Alabama	-$17.60/ton
Renton, Washington	-$43.80/ton
Illinois	-$3.00/ton
Average freight involved for disposing of clean coal	-$2.00/ton
Electricity	-1.5¢/KWH

Gas @ 6.5¢ per 100 cft. when more than
100,000 cft (used) - 6.5¢/100 cft.
Magnetite delivered at site - $48/ton
Annual Insurance rate during the
construction period - 27.3¢/$100
Annual Insurance rate for the plant - 50.7¢/$100

II. Cost of R.O.M. Coal

(a) Assuming 80% raw coals coming from the eastern region as Pennsylvania and West Virginia States, 10% from the southern region as Alabama and Oklahoma states and 10% local coal is from the state of Illinois. Therefore the average freight from these regions would be:

Eastern Region - $\$\left(\frac{5.19 + 4.82}{2}\right) = \$\,5.00$

Southern Region - $\$\left(\frac{16.40 + 17.60}{2}\right) = \$17.00$

Local, i.e. Illinois - $3.00

The average freight rate to transport raw coal from these three regions would be - 80% of $5.0 + 10% of $17.0 + 10% $3.0 or $6.0. Therefore the price of ROM coal delivered at Terre Haute, Indiana is $6+4.50 = $10.50.

(b) At the rate of 50 tons of raw coal per hour, one shift a day and 22 days a month, 8000 tons of coal will be washed per month, which means 96,000 tons per year. Considering a six months start-up period of the plant at a 50% operating rate and at a full rate of 50 TPH for three years, the estimated total raw coal processed in 3½ years would be:

96,000 x 1/4 _ 96,000 x 3
= 312,000 tons

Estimated total cost of raw coal at an estimated rate of $10.50 per ton (See Item a) is

$10.5 x 312,000
= $3,276,000

III. Selling Price of Washed Coal

(a) The estimated selling price of washed coal with 1 to 1.50% sulfur at the plant site is $5.95. Considering an average freight rate of $2.0 per ton for the transportation of the coal, the delivered cost of the washed coal is estimated to be $ (5.95 - 2) or $3.95.

(b) Estimated recovery of washed coal for a period of 3 ½ years at an average recovery of 85% and 95% plant efficiency is

312,000 x .85 x .95 tons
= 251,940 tons

Estimated selling price of washed coal at the rate of $3.95 per ton (See Item 14) is 251,940 x $3.95
= $995,163

IV. Personnel requirement for the preparation plant (this does not include laboratory personnel).

(a) Administrative & Office Personnel -

1	Project Manager (McNally) -	$20,000 per annum
1	Coal Preparation Engineer (Peabody)-	$20,000 per annum
1	Technical Advisor -	$20,000 per annum
1	Asst. Technical Advisor -	$15,000 per annum
1	Office Manager -	$15,000 per annum
1	Accountant -	$12,000 per annum
1	Stenographer -	$ 8,000 per annum
7		$110,000 per annum

(b) Operating Personnel* -

1	Plant Foreman - @$14,000 per annum -	$14,000 per annum
1	Loading Operator - @$11,200 per annum-	$11,200 per annum
1	Plant Operator - @$11,200 per annum -	$11,200 per annum
2	Ground men W.C. - @$11,200 per annum -	$22,400 per annum
2	Ground men R.C. - @$11,200 per annum -	$22,400 per annum
2	Maintenance men - @$11,200 per annum -	$22,400 per annum
9		$103,600 per annum

(c) Maintenance Personnel* -

1	Mechanical Foreman - @$14,000 per annum	$14,000 per annum
1	Mechanic - @ $11,200 per annum -	$11,200 per annum
1	Welder - @$11,200 per annum -	$11,200 per annum
1	Electrician - @$13,000 per annum -	$13,000 per annum
1	Labor - @$11,200 per annum -	$11,200 per annum
5		$60,600 per annum

*Wage rate of the operating and maintenance personnel is based on the current rates of U.M.W. in the state of Indiana.

V.

(a) The estimated insurance on the capital investment of $2,158,000 during the erection period of 1 year at the rate of 27.3¢ per $100 would be $5891.

(b) The estimated insurance on the capital investment of $2,158,000 during the three years operation and six months start-up of the plant at the rate of 50.7¢ per $100 would be $10,941. For 3½ years it would be $38,293.

Therefore, the total estimated insurance for 4½ years would be $44,185.

VI. The estimated depreciation on the capital investment at the end of 3½ years is $2,158,000 x .90 = $1,942,200.

The final depreciated value of the plant is $2,158,000 x 0.10 = $215,800.

VII. Estimated Start-Up Cost
(6 months)

		Total
Labor	-$137,100	
30% Fringe benefit, 5% overhead & 8% profit on labor	-$ 66,315	$203,415
Magnetite 50 tons @$48 per ton	-$ 2,400	$ 2,400
Spare Parts @2% per annum on capital investment of $2,158,000		$ 21,580
Power 1,605,858 KWH per annum @1.5¢ per KWH		$ 24,087
Gas 2,850,000 cft. per annum @6.5¢ per 100 cft.		$ 1,853
Total		$253,335

VIII. Estimated Operating Cost

		Annual	For 3-year
Labor	$274,200		
30% Fringe benefit, 5% overhead &8% on labor	$132,630		
		$406,830	$1,220,490
Magnetite 100 tons per annum @$48 per ton		$ 4,800	$ 14,400
Spare parts @ 2% per annum on capital investment of $2,158,000		$ 43,160	$ 129,480
Power 3,211,716 KWH per annum @1.5¢ per KWH		$ 48,175	$ 144,525
Gas 5,700,000 cft. per annum @6.5¢ per 100 cft.		$ 3,705	$ 11,115
Total		$506,670	$1,520,010

IX. The estimated equipment investment	$2,158,000
Start Up Cost	$ 253,335
Operating cost for 3 years	$1,520,010
Insurance for 4½ years	$ 44,185
Total	$3,975,530
less depreciated value of the plant (10% of equipment and installation cost)	$ 215,800
Total	$3,759,730

X. The running cost of the prototype plant per ton of raw coal washed:

$3,759,730/312,000 = $12.0

XI1 Summary	Laboratory	Prototype Plant	Total
Estimated equipment investment	$1,078,191	$2,158,000	$3,236,191
Start-up cost for 6 months	$ 911,514	$ 253,335	$1,164,849
Operating Cost for 3 years	$5,430,000	$1,520,010	$6,950,010
Insurance for 4½ years	$ 11,540	$ 44,185	$ 55,725
Total			$11,406,775
Less depreciated value (10% of the investment)	$ 107,819	$ 215,800	$ 323,619
			$11,083,156

This does not include the cost of raw coal and the sale price of washed coal.

XII. The total running cost of the plant and the laboratory would be $11,083,156/312,000 = $35.50 per ton of raw coal washed.

SECTION 3

ECONOMIC FEASIBILITY

Aside from the great desirability of eliminating pollutants from the air we breathe, the air pollution abatement requirements by various Federal laws now in force place the consumers of coal in a position of having to solve the problem of reducing SO_2 content in the flue gas.

As indicated earlier, electric utilities are the largest single category of coal consumers and, of course, air pollution control effects will be needed most in the densely populated industrial areas of states like California, Indiana, Illinois, New Jersey, New York, Ohio and Pennsylvania. The larger industrial coal users along with the public utilities can likely justify the installation of flue gas cleaning processes to recover sulfur and thus reduce the SO_2 content of the stack emission to acceptable levels. Smaller industrial coal users in these industrial areas would be obliged to burn low sulfur coal as the most economical solution, in spite of the higher cost, if they are to meet air pollution control regulations. Relocation of their plants in less densely populated areas where the need for air pollution abatement is not so stringent would be only a temporary solution since air pollution control requirements will most likely be increased in all industrial areas in the next few years. Thus the demand for low sulfur coals will surely increase as fast as the supply, which means that there will be more and more pressure in the immediate future for developing improved, economical methods for removing sulfur from coals.

From the data made available to us by the Air Pollution Control Division of HEW, we have given study of the economics of producing low sulfur coals careful consideration; although we do not have sufficient cost data, we can outline the possible credits which may be realized from using conventional methods of reducing the sulfur content in raw coals.

Tables II to VI show various coals whose sulfur content could be reduced substantially through normal beneification methods. Outside of meeting the need for sulfur removal, the reduction in ash content of the coal during beneficiation alone, in most cases, will justify these costs because of: (1) the increase in BTU content; (2) the reduction in weight prior to shipment; and (3) the substantially reduced cost in ash disposal costs at the point of usage. Thus, it can be said that the conventional coal beneficiation operation will, depending upon the washability characteristics of the coal, pay for itself fully in most cases by the increase in value of the washed coal, the meeting of the essential requirement for sulfur reduction being a substantial, added benefit Another valuable by-product in many cases, again depending upon the coal characteristics, will be the recovery of pyrite from the coal refuse stream.

The economics of using low sulfur coals depends upon the following:

(a) Reduction in ash during beneficiation process
(b) Sulfur content in the raw coal
(c) Ease of removal of sulfur from the coal
(d) Sulfur level in the washed coal
(e) Price of low sulfur coal
(f) Credit for pyrite produced
(g) Tonnage rate of coal washed
(h) Freight costs in transporting raw coal (if coal preparation plant is not at the mine)
(i) Freight costs in transporting washed coal to point of usage

These points are explained in further detail below:

(a) Reduction in Ash During Beneficiation Process--

As indicated above, there are other advantages in the reduction of sulfur content of raw coal to meet air pollution requirements. The process of reducing the sulfur in coal also reduces the extraneous ash bearing mineral matter. It is usually easier to remove the ash than it is to remove the sulfur, but the normal beneficiation process for ash removal does reduce the sulfur sufficiently in many cases to meet air pollution control requirements. If it is necessary to decrease the sulfur content beyond that obtained through normal ash removal operations, the further sulfur removal will also likely reduce the ash content to a lower level, but at the cost of a lower yield of washed coal. FOR EXAMPLE, Figure 14 shows curves for CT-29 in Pennsylvania. Washing this coal to 10% ash content, which is normally a satisfactory ash level for steam coals, would give a theoretical recovery of 81.5% with a total sulfur content of 1.32%. Of course to obtain a 1% sulfur level in the washed coal, the theoretical recovery would be only 50% with a 5% ash content. This amount of sulfur reduction would therefore be very costly.

The curves of Figure 15 show another example in which a 10% ash content for CT-28 in Pennsylvania, the theoretical yield would be 78.7% with a total sulfur level of 1.52% in the washed coal. To bring this sulfur level down to 1.00% would again be costly, since the recovery would be reduced to 34.3% with an ash level of 4.2%.

These two examples also show cases in which to achieve a satisfactory recovery the ash content should not be reduced below about 10% and in which the sulfur content at that ash level is at a reasonable level.

(b) Sulfur Content in the Raw Coal--

The nature and the amount of the sulfur present in the raw coal has an especially important bearing upon the economics of the beneficiation process. To meet a low sulfur level in the washed coal requires that the organic sulfur content in the raw coal be less than the sulfur level desired in the washed coal. As an example, if the washed coal is to meet a maximum level of a 1% total sulfur content, the raw coal must not have more than a content of 1% of organic sulfur. Since organic sulfur is usually present in coal in a disseminated form, it is very difficult to reduce through the normal

FIG. 14

Upper Freeport Seam
CT-29
Pennsylvania

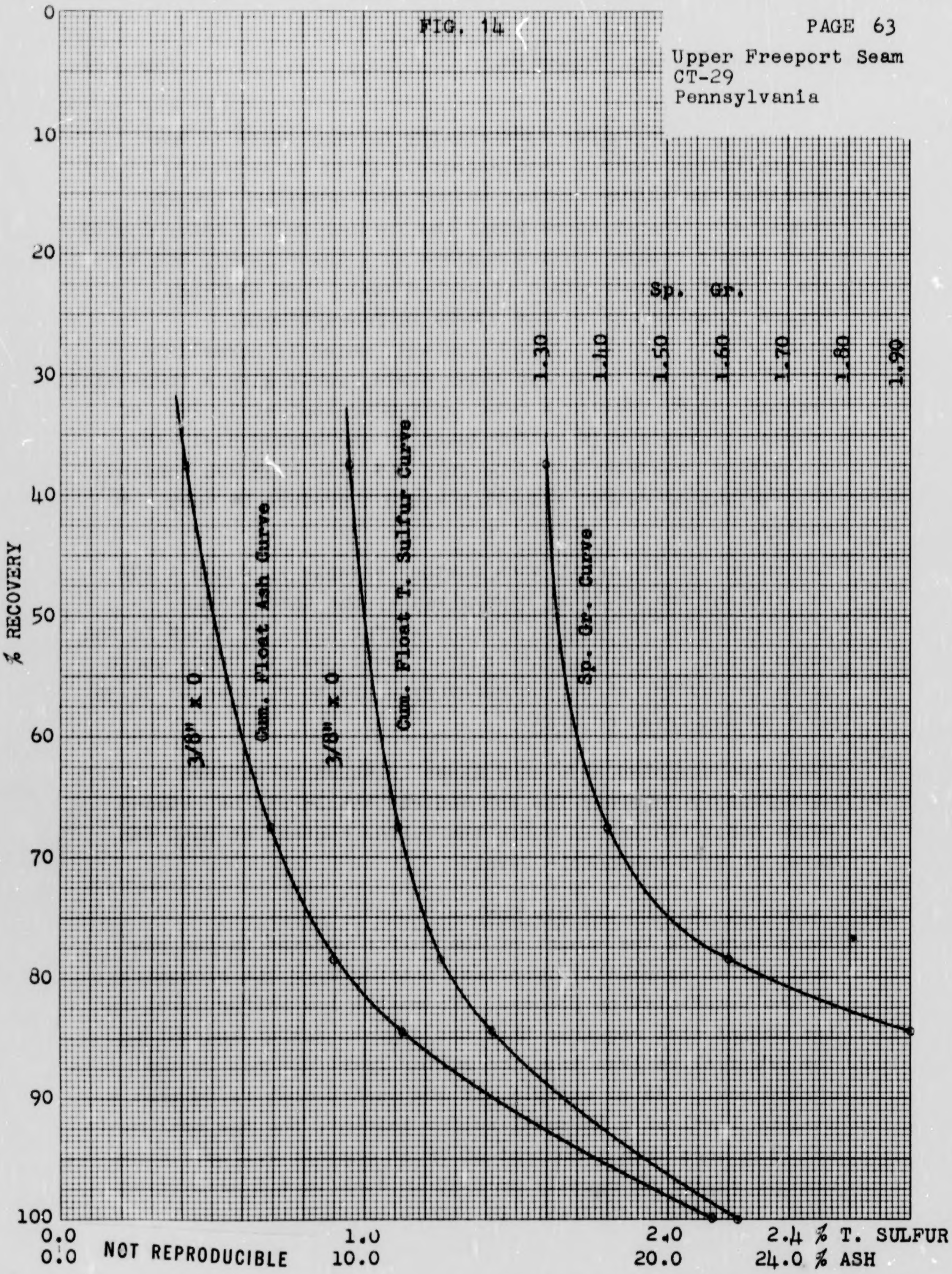
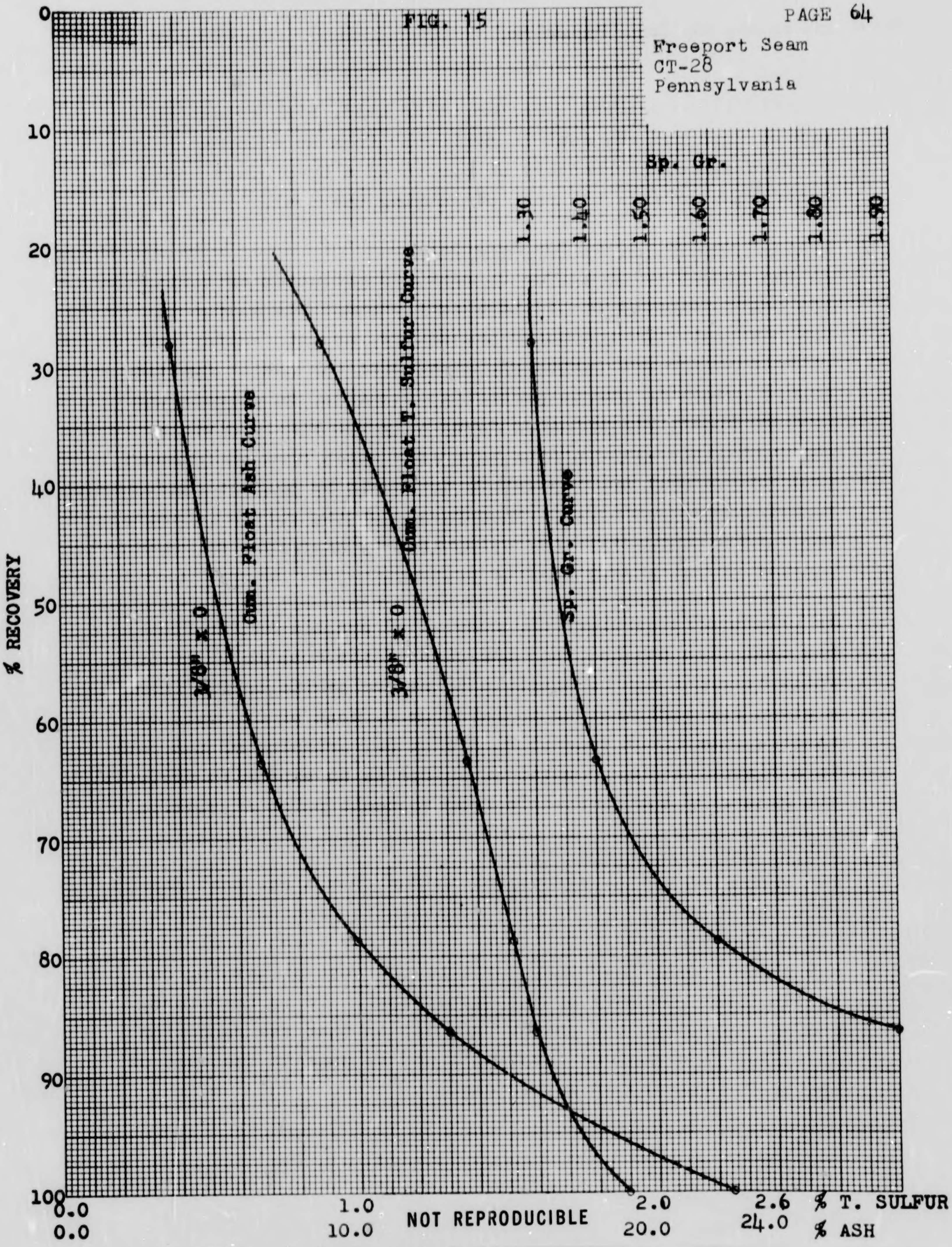


FIG. 15


Freeport Seam
CT-28
Pennsylvania

beneficiation process. On the other hand, high recoverable pyrite from the raw coal is desirable from an economic point of view since the recovery of pyrite as a by-product would contribute towards the cost of washing the coal.

(c) Ease of Removal of Sulfur From Coal--

In the reduction of sulfur to meet air pollution criteria, the coals selected should have easily removable sulfur in the raw coal. As indicated previously, organic sulfur and sulfate sulfur are intimately mixed with the coal. Pyritic sulfur occurs in coarse particles, in bands, in pockets and even in finely disseminated form; only the finely divided and intimately mixed pyrite particles which form an inherent part of the coal are impossible to remove by present conventional beneficiation processes. Therefore, pyritic sulfur in coarse form and occuring in bands or pockets is desirable for the success of the normal washing process.

As illustrated earlier, the removal of pyritic sulfur from raw coal also depends upon the size of the coal to be washed. While it might not be possible to remove pyrite sulfur from a given raw coal crushed to 1-1/2" x 0, most of it could be removed when it is crushed to 3/8" x 0. Crushing of raw coal to a finer size for removal of sulfur is an expensive proposition and generally not worthwhile from economic point of view.

(d) Sulfur Level in Washed Coal--

The economics of the removal of sulfur from a raw coal depend upon the criteria set by the air pollution control authorities for different areas. The lower the sulfur level required in the washed coal, the higher will be the cost of washing due to the lower recovery of the washed coal. It is therefore, prudent to select the proper raw coal so that the reduction of sulfur to a desired level will not be done at the cost of too low a recovery of washed coal.

(e) Tonnage of Coal Washed--

The amount of coal to be washed depends upon factors like financial resources, availability of raw material near to the preparation plant, and the demands for low sulfur coal and pyrite. Normally, the larger the capacity of a plant, the lower will be the operating cost per ton of coal washed.

(f) Price of Low Sulfur Coal--

The premium in price for low sulfur coal is one of the most important factors required for the coal companies to justify investment in coal preparation plants for sulfur reduction, especially in those cases in which to achieve the desired sulfur level the coal characteristics require washing at a lower yield than would be necessary to reach economical ash levels. The price premium for low sulfur coal at present does not justify any appreciable investment but it is anticipated that the more stringent air pollution requirement of the future, when suitably enforced, will create a much greater demand, even at an enhanced price, for the low sulfur coals. Besides conforming to the air pollution requirements, the low sulfur coals will have the following additional advantages:

I. Lower pulverization cost due to lower pyrite content.
II. Reduction in corrosion in the boiler tubes, preheaters, etc. because of the reduction in the abrasive index of the washed coal, again due to the lower pyrite content.

(g) Credit for Pyrite Produced--

The pyrite produced as a by-product could be sold to the sulfuric acid manufacturers or used in other sulfur processes to recover a portion of the beneficiation costs.

(h) Freight in Transporting Raw Coal--

Freight involved in transporting raw coal can play a significant part in the economics of the process; obviously longer the distance the raw coal has to be transported, the higher will be the cost of low sulfur coal. It is, therefore, desirable that the coal preparation plant be centrally located and, if possible, near to the raw material and to the clean coal market.

(i) Freight Costs in Transporting Clean Coal--

The presently known low sulfur raw coal reserves are generally in the Pennsylvania, West Virginia, Kentucky and Ohio areas. This means that higher sulfur raw coals in other areas will likely have to be beneficiated to reduce the sulfur to acceptable levels. Thus transportation costs of the washed coal will affect the economics of such operations.

PART VI

CONCLUSION, ACKNOWLEDGEMENT & BIBLIOGRAPHY

SECTION 1

CONCLUSION

As explained earlier, the objects for considering the construction and operation of the proposed pilot plant are:

(a) To demonstrate in actual practice, the percentage of reduction of total sulfur and pyritic sulfur for a given recovery of washed coal from a raw coal selected for processing; it will also be possible in this way to obtain a comparison of actual performance to the predicted performance based upon results obtained from the testing of bulk samples.

(b) To demonstrate the percentage of recovery of pyrite from the washery refuse for various coals.

(c) To select a suitable process as well as items of equipment for maximum recovery of washed coal at a given sulfur level.

(d) To evaluate the cost of washing in a commerical size operation for each coal processed.

To meet the above requirement, a test/pilot plant with the best available processes in current use in coal preparation technology has been designed. Being a pilot plant for an extensive testing program, flexibility has been designed into the circuits as well as in the choice of the process equipment to assure proper assessment of the wide range of washability characteristics likely to be encountered in the operation of this plant.

Because of the continued growth of mechanical mining practices, more complex coal cleaning plants are required in order to remove the extra ash bearing and other extraneous material and to treat the larger quantity of coal fines produced. In the process of reducing ash in coal, a portion of the sulfur (depending upon its nature) present is also removed. Compared to ash removal, sulfur is usually more difficult to remove because of the nature of the sulfur content in the coal. Therefore the reduction of sulfur to a level of less than 1.5% in clean coal is achieved in most cases at the cost of a lower recovery of washed coal.

Work on the reduction of sulfur from coal has been attempted through crushing, screening, gravity separation, froth flotation, tabling, electro-static separation, electro-magnetic separation and in many other ways. Some of these processes do yield satisfactory results in the reduction of sulfur, almost always depending upon the characteristics of the sulfur in the coal. But there is currently no suitable conventional, economical process for removing the finely disseminated pyritic sulfur or organic sulfur from the raw coal; it is usually accomplished only at a substantial sacrifice in the yield of clean coal.

Another major factor in the demand for coal's sulfur reduction will be for the gasification and liquefaction of coal. The present demand for petroleum products in this country is about four billion barrels per year and by 1980 this demand will be six to eight billion barrels; by the year 2000, twelve to fifteen billion barrels per year (6). At the present depletion rate, known oil reserves will last only until the 1980's. According to the Institute of Gas Technology, Chicago, Illinois, known gas reserves in this country are approximately 300 trillion cubic feet; the net addition to the U.S. reserves have been very low in recent years. At the present rate of consumption, known gas reserves will last for another 15 year (27). In the U.S.A. the minimum projected demand for gas through the year 2000, assuming that the gas can be made available, totals over 1000 trillion cubic feet.

Known coal reserves, by contrast to the above, will last until 2280's (23). The obvious replacement for these depleted oil reserves is coal, which is the reason for the current development activity in this field. To meet the requirements for petroleum products and natural gas substitutes, as well as future anti-pollution requirements, sulfur removal from the coal will be necessary either during the gasification or liquefaction process or prior to it.

NOTE: Number in parenthesis refers to bibliographic reference, Refer Pages 76 and 77.

Extensive work is being done by various organizations throughout the world to find improved methods for reducing sulfur in coal, but emphasis is greatest in the U.S.A. at this time due to the great need for burning coal with low sulfur emission. Using current preparation technology, the theoretical as well as the actual clean coal recovery can be predicted at different ash levels. Similarly the theoretical as well as the actual recovery of clean coal can be predicted at different sulfur levels. To be able to make these predictions, of course, will require extensive field work in the collection of bulk samples, laboratory tests to determine the washability characteristics of coal, the extent and the nature of the occurrence of the pyritic sulfur in the coal, the additional liberation of sulfur by crushing, and the amount of the organic sulphur present in the raw coal.

From the detailed studies described in this report, made possible by the extensive test data supplied through HEW, it is evident that there are problems involved in meeting all of the testing and operating requirements which have been uncovered by these studies. Coupling these problems with the amount of test data to be developed within the time periods outlined has culminated in the design of an operating and testing facility requiring capital, testing, and operating costs of magnitudes which deserve careful thought and study before a decision is made to proceed with the program as it has thus far been outlined. We would therefore suggest that consideration be given to the following different alternates:

1. A 50 TPH prototype plant has been selected for this study on the basis of various discussions held with HEW officials. From our investigation and cost analysis we are led to the conclusion

that some consideration should be given to the construction of a full scale commercial plant primarily because the capital investment will be much more effectively used in building the larger plant. The laboratory costs would be approximately the same in either case, and it would be of advantage to conduct certain tests both at 50 TPH and at the commercial rate of 1000 TPH. At the end of the program the larger plant would be of substantial value both from a scientific and commercial standpoint. From a cost standpoint, administrative, office and laboratory personnel would be at about the same level for either a test or a commercial size plant.

Because of freight costs involved in moving the test coals, it would be desirable to do most of the test work at 50 TPH, but the capacity would be available both for full scale testing purposes or for Commercial operation on local or other coals during non testing periods.

We suggest the question: Should a new commercial size operating plant be constructed which could treat and test, say, 1000 TPH, but which would be designed with sufficient flexibility to handle and test at low (50 TPH) feed rates?

Close cooperation with a large coal company would probably be necessary to assure that the suggested alternative would become a financial success; or this 1000 TPH test/operating plant might also serve a very useful purpose if it were run as a cooperative venture by a group of coal companies through the National Coal Association or the Bituminous Coal Research. The additional cost for the 1000 TPH test and operating capacity should be worth consideration, especially if the 1000 TPH capacity could be a deciding factor in the disposal of the facility through some prearranged agreement with the operating coal company or group of companies.

2. Since major contributions to both Capital and Operating Costs are the laboratory and testing facilities and procedures, some consideration should be given to the use of existing central testing laboratories (with expanded facilities and manpower if necessary), rather than to have to build all of the extensive facilities which are contemplated by this study.

The laboratory and the large manpower requirement are to a major extent dictated by the short operating and testing cycles which have been set as objectives for each different coal. Obviously, either fewer tests or the availability of a longer time period for the completion of each set of tests would reduce both the capital and the daily operating costs. In the final analysis, such savings should be balanced against the present anticipated requirement for complete and timely test results.

3. Another approach would be to seek cooperation from various coal operators to use their cleaning plants which are strategically located in relation to the sources of the coals to be tested; arrangements could be made to add temporary modifications to the plant in question both by adding the necessary extra processing equipment when required and any necessary sampling equipment to assure the use of the proper cleaning methods and the collection of samples of the coals at desired points in the plant. These samples could then be tested at the nearest available, suitable testing laboratory. If such sampling and testing procedures could always be supervised by the same personnel, this would help to attain consistency of results for comparative purposes; in any event, care could be exercised to assure the meeting of accepted and consistent sampling and testing standards.

4. Experienced coal washery contractors are able to predict accurately ash, moisture and sulfur levels in washed coal, provided washability data is available on reliable samples of the coal to be washed. This capability is based on the use of beneficiation equipment currently in use in the industry. In view

of the fact that this study has produced no new beneficiation processes whose effectiveness on a wide variety coals need to be tested, we recommend that the proposed pilot and testing plant not be built.

5. If extreme flexibility were required, the future full scale plant could be designed to produce clean coal which would meet the desired sulfur level requirements from a very wide range of raw coals; as illustrated by this study, however, low sulfur levels would sometimes be produced at high costs, either due to having to clean the coal at fine sizes and/or at a sacrifice in yield. This suggested approach, combined with some prior tests on certain coal cleaning and pyrite separation equipment, should be able to provide all of the results desired from this proposed Pilot/Test Plant.

Some of the above suggestions, as indicated, have resulted from the studies made under this contract and are, of course, offered with the likely disadvantage of an incomplete background of significant information which might affect your decision as to the best course of action.

6. As required by the scope of work, we are to give an estimate of our costs to develop the estimated cost for analysis of data to be generated by the prototype plant study and the estimated cost to develop flowsheets and cost estimates for full-scale plants. As the washability characteristics of 36 coals to be washed during 3 year period may vary considerably, it is not possible to predict the number of different full scale plant flowsheets and cost estimates required.

For the purpose of developing flowsheets from the data generated in the prototype plant, we assume the following:

- a) All plants will have the same capacity, say 1000 TPH.
- b) Same design of raw coal receiving and handling system will be used for all plants.
- c) Same type of clean coal loading system will be used.

- d) Maximum coal size 1-1/2" x 0, minimum 14M x 0.
- e) Plant will be basically a heavy media cycloid and hydro-cyclone type, and
- f) Fluid bed type thermal dryer will be provided.

Taking the above assumptions into account, our estimated costs are as follows:

1) For 30% accuracy in the estimate (with a set of flowsheets, a set of unit lists, and an approximate estimate of the plant)
   -\$5,000 for the first plant and \$2,500 for each additional plant requiring a different flowsheet.
2) For 20% accuracy in the estimate (with a set of flowsheets, a set of unit lists complete with specification, and an approximate estimate)
   -\$10,000 for the first plant and \$5,000 for each additional plant requiring a different flowsheet.
3) For 10% accuracy in the estimate (with a complete proposal together with a set of flowsheets, unit lists, specification of the plant and equipment, a set of 1/8" design drawings, and a detailed estimate)
   -\$50,000 for the first plant and \$25,000 for each additional plant requiring a different flowsheet.

SECTION 2

ACKNOWLEDGEMENT

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Information was also gathered from different literature, publication, statistical data and discussions held with the responsible personnel including Messrs. Paul W. Spaite, T. Kelly Janes and E. A. Zawadzki of the Department of Health, Education and Welfare. We also received valuable advice from Messrs. Edwin R. Phelps, A. L. Massmann, George Morris, Ezra Smith, Elroy Kaetsch and others of Peabody Coal Company. We are grateful to all these gentlemen for their cooperation and valuable advice.

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TABLE I, Page 1

APPENDIX - A

RAW COAL WITH LESS THAN 1.0%, 1.0% TO 1.5% AND 1.5% TO 2.0% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Recovery
LESS THAN 1.0%								
ALABAMA Jefferson Mary Lee BM-93	3/8" x 0	0.63	0.15	16.40	0.63	0.12	9.00	87.8
PENNSYLVANIA Clarion Middle Kittanning CT-63	3/8" x 0	0.71	0.12	7.91	0.69	0.10	6.52	98.6
1.0% TO 1.5%								
ALABAMA Jefferson Mary Lee BM-94	3/8" x 0	1.12	0.54	16.30	0.99	0.32	8.10	75.8
ILLINOIS Jefferson No. 6 CT-58	3/8" x 0	1.41	0.82	21.52	1.25	0.55	9.02	84.3
Jefferson No. 6 BM-16	3/8" x 0	1.18	0.61	12.30	0.98	0.34	5.20	49.1

APPENDIX - A

TABLE I, Page 2

RAW COAL WITH LESS THAN 1.0%, 1.0% TO 1.5% AND 1.5% TO 2.0% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
ILLINOIS Franklin No. 6 CT-60	3/8" x 0	1.16	0.62	15.52	0.95	0.35	7.11	90.0
PENNSYLVANIA Cambria Lower Kittanning CT-3	3/8" x 0	1.29	0.81	24.20	0.69	0.22	13.62	82.4
Cambria Upper Kittanning CT-49	3/8" x 0	1.18	0.79	34.36	0.68	0.17	9.13	62.1
Jefferson Lower Kittanning BM-49	3/8" x 0	1.35	0.59	8.50	0.87	0.11	3.40	54.7
Butler Upper Freeport BM-96	3/8" x 0	1.33	0.76	19.40	0.98	0.40	8.70	79.9
WEST VIRGINIA Monongalia Waynesburg BM-103	3/8" x 0	1.34	0.63	15.60	1.26	0.54	13.20	93.6

The McNally Pittsburg Mfg. Corp.

APPENDIX - A

RAW COAL WITH LESS THAN 1.0%, 1.0% TO 1.5% AND 1.5% TO 2.0% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Recovery
1.5% TO 2.0%								
ALABAMA Jefferson Gwin BM-95	3/8" x 0	1.79	1.12	15.90	1.49	0.71	9.50	64.0
Walker America BM-91	3/8" x 0	1.73	0.94	14.10	1.41	0.52	6.90	83.8
INDIANA Vigo No. 7 BM-67	3/8" x 0	1.57	1.05	12.10	0.91	0.38	8.20	92.5
Sullivan No. 7 BM-70	3/8" x 0	1.88	1.26	10.50	1.14	0.50	8.10	95.0
OHIO Harrison Swickley BM-29	3/8" x 0	1.92	1.24	10.60	1.36	0.71	9.20	96.0

APPENDIX - A

RAW COAL WITH LESS THAN 1.0%, 1.0% TO 1.5% AND 1.5% TO 2.0% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
OHIO								
Jefferson								
Mahoning								
CT-40	3/8" x 0	1.52	0.91	9.53	0.78	0.26	6.03	95.0
PENNSYLVANIA								
Cambria								
Lower Kittanning								
CT-16	3/8" x 0	1.58	0.89	12.61	0.79	0.19	8.53	92.2
Indiana								
Upper Freeport								
CT-19	3/8" x 0	1.70	1.19	15.00	0.94	0.42	6.07	83.9
Armstrong								
Double Freeport								
CT-32	3/8" x 0	1.86	1.27	27.85	0.94	0.24	3.91	37.3
Allegheny								
Double Freeport								
CT-28	1½" x 0	1.92	1.36	22.44	0.88	0.34	3.80	28.1
Washington								
Pittsburgh								
BM-39	3/8" x 0	1.72	0.88	8.60	0.95	0.17	3.30	55.2

APPENDIX - A

RAW COAL WITH LESS THAN 1.0%, 1.0% TO 1.5% AND 1.5% TO 2.0% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
PENNSYLVANIA Washington Pittsburgh BM-44	3/8" x 0	1.67	0.80	9.30	1.36	0.47	5.40	92.8
Tioga Upper Freeport BM-51	3/8" x 0	1.50	1.01	10.20	0.88	0.36	8.40	95.9
WEST VIRGINIA Preston Upper Freeport CT-21	3/8" x 0	1.65	1.11	13.62	0.88	0.36	8.30	91.7
Monongalia Pittsburgh BM-19	3/8" x 0	1.87	1.01	9.40	1.42	0.58	7.90	96.4

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APPENDIX - B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
ALABAMA Jefferson Mary Lee BM-93	3/8" x 0	0.63	0.15	16.40	0.63	0.12	9.00	87.8
Jefferson Mary Lee BM-94	3/8" x 0	1.12	0.54	16.30	0.99	0.32	8.10	75.8
ILLINOIS Jefferson No. 6 BM-16	3/8" x 0	1.18	0.61	12.30	0.98	0.34	5.20	49.1
Franklin No. 6 CT-60	3/8" x 0	1.16	0.62	15.52	0.95	0.35	7.11	90.0
INDIANA Vigo No. 7 BM-67	3/8" x 0	1.57	1.05	12.10	0.91	0.38	8.20	92.5
Sullivan No. 7 BM-70	14M x 0	1.84	1.19	10.40	0.97	0.32	5.30	75.0

The McNally Pittsburg Mfg. Corp.

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APPENDIX B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
IOWA Mabaska Lower Cherokee BM-31	14M x 0	2.63	1.80	7.20	0.94	0.18	3.40	89.2
OHIO Mahoning No. 4 CT-11	3/8" x 0	2.72	1.76	7.88	0.85	0.18	1.54	66.5
Columbiana No. 6 CT-7	3/8" x 0	2.54	1.75	9.79	0.75	0.25	2.61	68.0
Columbiana No. 6 CT-41	3/8" x 0	2.40	1.67	10.97	0.66	0.21	5.35	92.2
Harrison No. 6A CT-9	3/8" x 0	2.50	1.77	10.83	0.85	0.16	2.75	63.6
Harrison Sewickley BM-29	14M x 0	2.04	1.21	10.50	0.82	0.16	3.80	44.8

APPENDIX B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
OHIO Muskingum Lower Kittanning CT-52	3/8" x 0	5.08	3.69	11.39	0.97	0.27	2.88	68.6
Jefferson Mahoning CT-40	3/8" x 0	1.52	0.91	9.53	0.78	0.26	6.03	95.0
PENNSYLVANIA Armstrong Upper Freeport CT-69	3/8" x 0	3.40	2.28	16.38	0.92	0.16	3.32	53.7
Armstrong Upper Freeport CT-66	3/8" x 0	2.56	1.67	12.94	0.93	0.24	4.79	80.2
Armstrong Upper Freeport CT-29	3/8" x 0	2.23	1.61	21.38	0.89	0.24	5.89	67.9
Armstrong Double Freeport CT-32	3/8" x 0	1.86	1.27	27.85	0.96	0.24	3.91	37.3

APPENDIX B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
PENNSYLVANIA **Westmoreland** **Upper Freeport** **CT-15**	3/8" x 0	3.46	2.78	21.62	0.87	0.32	3.27	55.8
Washington **Pittsburgh** **BM-39**	3/8" x 0	1.72	0.88	8.60	0.95	0.17	3.30	55.2
Cambria **Lower Kittanning** **& Lower Freeport** **CT-2**	3/8" x 0	2.63	1.75	15.52	0.93	0.26	4.06	77.6
Cambria **Lower Kittanning** **CT-16**	3/8" x 0	1.58	0.89	12.61	0.79	0.19	8.53	92.2
Cambria **Upper Kittanning** **CT-49**	3/8" x 0	1.18	0.79	34.36	0.68	0.17	9.13	62.1
Cambria **Lower Kittanning** **CT-3**	3/8" x 0	1.29	0.81	24.20	0.69	0.22	13.62	82.4
Allegheny **Double Freeport** **CT-28**	3/8" x 0	2.02	1.54	22.79	0.80	0.27	5.31	61.9

APPENDIX B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
PENNSYLVANIA Bedford Lower Kittanning BM-52	3/8" x 0	2.08	1.42	13.30	0.91	0.26	6.10	84.9
Lawrence Brookville BM-50	3/8" x 0	2.38	1.83	4.80	0.88	0.37	2.20	92.9
Clarion Upper Clarion CT-64	3/8" x 0	2.40	1.50	15.10	0.86	0.12	3.40	64.6
Clarion Middle Kittanning CT-63	3/8" x 0	0.71	0.12	7.91	0.69	0.10	6.52	98.6
Somerset 'C' Prime CT-4	3/8" x 0	2.64	2.10	15.55	0.82	0.35	8.02	87.0
Clearfield 'D' Seam CT-51	3/8" x 0	2.73	1.78	11.58	0.85	0.19	3.31	62.2
Indiana Lower Freeport CT-67	3/8" x 0	2.36	1.69	20.39	0.92	0.25	4.87	65.9

APPENDIX B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
PENNSYLVANIA Indiana Upper Freeport CT-19	3/8" x 0	1.70	1.19	15.00	0.89	0.34	4.99	78.4
Jefferson Lower Kittanning BM-49	3/8" x 0	1.35	0.59	8.50	0.87	0.11	3.40	54.7
Tioga Upper Freeport BM-51	3/8" x 0	1.50	1.01	10.20	0.88	0.36	8.40	95.9
Butler Upper Freeport BM-96	3/8" x 0	1.33	0.76	19.40	0.98	0.40	8.70	79.9
WEST VIRGINIA Grant Bakerstown CT-23	3/8" x 0	3.02	2.38	27.63	0.95	0.41	11.45	65.2
Grant Freeport CT-22	3/8" x 0	2.44	1.80	34.30	0.81	0.12	2.79	11.2

APPENDIX B

WASHED COAL WITH TOTAL SULFUR LESS THAN 1.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
WEST VIRGINIA								
Preston								
Upper Freeport								
CT-21	3/8" x 0	1.65	1.11	13.62	0.88	0.36	8.30	91.7
Barbour								
Middle Kittanning								
BM-83	3/8" x 0	2.02	1.49	15.20	0.90	0.32	6.80	76.0

APPENDIX - C

WASHED COAL WITH TOTAL SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Recovery
ALABAMA Walker America BM-91	3/8" x 0	1.73	0.94	14.10	1.41	0.52	6.90	83.8
Walker Clement BM-92	3/8" x 0	3.77	2.83	13.80	1.20	0.31	2.80	35.0
Jefferson Gwin BM-95	3/8" x 0	1.79	1.12	15.90	1.49	0.71	9.50	64.0
Jefferson Mary Lee BM-94	3/8" x 0	1.12	0.54	16.30	1.09	0.45	10.00	88.0
ILLINOIS Jefferson No. 6 CT-58	3/8" x 0	1.41	0.82	21.52	1.25	0.55	9.02	84.3
Jefferson No. 6 CT-59	3/8" x 0	2.48	1.59	19.77	1.41	0.43	3.62	42.0

APPENDIX C

WASHED COAL WITH TOTAL SULFUR - 1.0% to 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
ILLINOIS Jefferson No. 6 BM-16	3/8" x 0	1.18	0.61	12.30	1.01	0.43	9.70	93.9
Saline No. 5 CT-56	3/8" x 0	3.29	2.38	18.79	1.37	0.42	2.98	33.1
INDIANA Sullivan No. 7 BM-74	3/8" x 0	1.88	1.26	10.50	1.14	0.50	8.10	95.0
IOWA Mabaska Lower Cherokee BM-31	3/8" x 0	2.54	1.76	7.10	1.18	0.41	4.60	95.1
KENTUCKY Hopkins No. 6 CT-36	3/8" x 0	2.64	1.80	16.39	1.23	0.37	1.70	40.2
OHIO Lawrence Lower Kittanning CT-25	3/8" x 0	4.78	3.57	14.40	1.03	0.41	3.12	57.0

APPENDIX C

TABLE III, PAGE 3

WASHED COAL WITH TOTAL SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
OHIO Muskingum Lower Kittanning CT-43	3/8" x 0	5.08	3.69	11.39	1.30	0.54	4.22	85.2
Harrison Sewickley-9 BM-23	3/8" x 0	2.17	1.39	10.90	1.45	0.61	8.50	87.8
Harrison Lower Freeport CT-8	3/8" x 0	2.41	1.54	9.93	1.35	0.53	4.07	84.9
Harrison Sewickley BM-29	3/8" x 0	1.92	1.24	10.60	1.36	0.71	9.20	96.0
Harrison No. 6A CT-9	3/8" x 0	2.50	1.77	10.83	1.43	0.70	5.50	92.8
Mahoning No. 4 CT-11	3/8" x 0	2.72	1.76	7.88	1.35	0.61	4.29	93.5
Jefferson No. 5-A CT-10	14M x 0	3.93	2.69	17.41	1.41	0.43	3.82	30.2

The McNally Pittsburg Mfg. Corp.

WASHED COAL WITH TOTAL SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
OHIO Jefferson Pittsburgh BM-58	14M x 0	3.00	2.04	9.80	1.41	0.34	3.30	56.7
Columbiana No. 6 CT-21	3/8" x 0	2.54	1.75	9.79	1.35	0.74	6.14	94.5
PENNSYLVANIA Armstrong Lower Freeport CT-33	3/8" x 0	2.31	1.50	12.31	1.35	0.61	7.64	89.3
Armstrong Lower Kittanning CT-68	3/8" x 0	3.98	2.88	23.49	1.39	0.52	5.09	60.3
Armstrong Upper Freeport CT-69	3/8" x 0	3.40	2.28	16.38	1.43	0.57	6.76	82.6
Indiana Lower Kittanning CT-17	3/8" x 0	5.12	3.77	14.34	1.24	0.46	3.46	53.6
Indiana Lower Kittanning CT-1	3/8" x 0	3.49	2.47	8.70	1.41	0.48	4.60	85.1

APPENDIX C

WASHED COAL WITH **TOTAL** SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
PENNSYLVANIA Indiana Lower Kittanning BM-47	3/8" x 0	4.58	3.86	21.00	1.47	0.65	6.80	73.1
Indiana 'B' Seam CT-70	3/8" x 0	3.44	2.22	12.67	1.35	0.42	4.28	79.9
Indiana Lower Kittanning CT-18	3/8" x 0	4.60	3.28	19.10	1.44	0.56	4.79	70.5
Indiana Lower Kittanning CT-46	3/8" x 0	4.26	2.80	17.35	1.38	0.37	4.16	70.2
Indiana Lower Freeport CT-67	3/8" x 0	2.36	1.69	20.39	1.05	0.39	8.76	81.6
Indiana Upper Freeport CT-19	3/8" x 0	1.70	1.19	15.00	1.03	0.49	7.45	87.6
Clarion Upper Clarion CT-64	3/8" x 0	2.40	1.50	15.10	1.19	0.42	8.13	89.4

The McNally Pittsburg Mfg. Corp.

APPENDIX C

TABLE III, PAGE 6

WASHED COAL WITH TOTAL SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
PENNSYLVANIA Clarion Lower Kittanning BM-60	3/8" x 0	3.82	2.68	10.50	1.25	0.35	3.20	53.5
Green Pittsburgh BM-20	14M x 0	2.60	1.30	8.10	1.44	0.21	3.90	60.9
Cambria Upper Freeport CT-47	3/8" x 0	4.56	3.27	18.33	1.32	0.53	5.51	69.2
Cambria Lower Kittanning & Lower Freeport CT-2	3/8" x 0	2.63	1.75	15.52	1.13	0.43	6.04	85.1
Washington Pittsburgh BM-39	3/8" x 0	1.72	0.88	8.60	1.37	0.53	5.40	93.2
Washington Pittsburgh BM-44	3/8" x 0	1.67	0.80	9.30	1.36	0.47	5.40	92.8
Jefferson Lower Kittanning BM-49	3/8" x 0	1.35	0.59	8.50	1.08	0.29	6.80	96.1

The McNally Pittsburg Mfg. Corp.

APPENDIX C

WASHED COAL WITH TOTAL SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Washed Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Recovery
PENNSYLVANIA Clearfield 'D' Seam CT-51	3/8" x 0	2.73	1.78	11.58	1.35	0.63	6.91	91.6
Clearfield 'E' Seam CT-62	3/8" x 0	3.25	2.10	14.41	1.29	0.53	4.03	38.2
Armstrong Double Freeport CT-32	3/8" x 0	1.86	1.27	27.85	1.16	0.45	12.14	75.1
Armstrong Upper Freeport CT-29	3/8" x 0	2.23	1.61	21.38	1.07	0.45	9.97	82.9
Westmoreland Upper Freeport CT-15	3/8" x 0	3.46	2.78	21.62	1.35	0.73	5.54	73.9
Allegheny Double Freeport CT-28	3/8" x 0	2.02	1.54	22.79	1.09	0.56	11.16	82.8
WEST VIRGINIA Grant Upper Freeport CT-22	3/8" x 0	2.44	1.80	34.30	1.39	0.70	15.35	69.1

APPENDIX C

WASHED COAL WITH TOTAL SULFUR - 1.0% TO 1.50%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
WEST VIRGINIA Grant Bakerstown CT-23	3/8" x 0	3.02	2.38	27.63	1.05	0.55	17.52	80.2
Monongalia Pittsburgh BM-19	3/8" x 0	1.87	1.01	9.40	1.42	0.58	7.90	96.4
Monongalia Pittsburgh BM-21	14M x 0	2.41	1.22	8.50	1.44	0.19	3.70	61.3
Monongalia Waynesburg BM-103	3/8" x 0	1.34	0.63	15.60	1.26	0.54	13.20	93.6
Marion Pittsburgh CT-14	14M x 0	2.40	1.22	10.46	1.40	0.16	3.11	66.6
Barbour Middle Kittanning BM-84	3/8" x 0	3.24	2.68	19.30	1.24	0.56	6.30	62.0

TABLE IV, PAGE 1

APPENDIX - D

WASHED COAL WITH TOTAL SULFUR - 1.50% TO 2.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Recovery
ILLINOIS Saline No. 5 CT-56	3/8" x 0	3.29	2.38	18.79	1.73	0.81	6.23	76.9
Jefferson No. 6 CT-59	3/8" x 0	2.48	1.59	19.77	1.82	0.84	8.90	86.2
Williamson No. 6 BM-77	3/8" x 0	3.18	2.02	14.10	1.90	0.57	6.10	78.2
Franklin No. 5 CT-54	3/8" x 0	3.14	1.83	12.98	1.93	0.55	5.28	78.9
INDIANA Sullivan No. 6 BM-68	3/8" x 0	2.86	1.93	15.50	1.87	0.85	5.80	78.6
KENTUCKY Muhlenburg No. 11 BM-76	3/8" x 0	4.58	3.30	17.20	1.93	0.49	4.20	28.6

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APPENDIX D

TABLE IV, PAGE 2

WASHED COAL WITH TOTAL SULFUR - 1.50% TO 2.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Recovery
KENTUCKY								
Muhlenburg No. 12 BM-81	3/8" x 0	2.62	1.89	15.90	1.86	1.05	7.90	76.9
Hopkins No. 6 CT-36	3/8" x 0	2.64	1.80	16.39	1.70	0.76	4.10	85.2
MARYLAND								
Allegheny Lower Bakerstown BM-104	3/8" x 0	2.55	1.94	19.90	1.82	1.11	14.20	82.9
Allegheny Upper Freeport BM-106	3/8" x 0	3.02	2.19	14.30	1.97	1.02	9.00	70.2
OHIO								
Jefferson No. 5A CT-10	3/8" x 0	4.00	2.68	17.46	1.95	0.85	5.58	71.5
Jefferson Pittsburgh BM-58	3/8" x 0	2.89	1.96	9.90	1.57	0.61	3.80	45.1

APPENDIX D

WASHED COAL WITH TOTAL SULFUR - 1.50% TO 2.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
OHIO								
Jefferson Pittsburgh CT-30	3/8" x 0	3.33	1.99	14.05	1.80	0.56	3.46	42.7
Gallia Pittsburgh BM-35	3/8" x 0	3.44	2.36	8.90	1.69	0.63	3.50	54.3
Perry No. 6 BM-38	3/8" x 0	4.25	3.18	17.80	1.92	0.80	5.10	67.1
Perry No. 6 CT-13	3/8" x 0	4.69	3.62	19.41	1.82	0.65	4.45	66.7
Muskingum No. 5 CT-43	3/8" x 0	3.10	1.30	6.86	1.93	0.26	3.13	75.9
Harrison Pittsburgh CT-20	3/8" x 0	3.43	1.99	13.01	1.71	0.32	3.58	52.5

APPENDIX D

WASHED COAL WITH TOTAL SULFUR - 1.50% TO 2.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
OHIO Lawrence No. 5 CT-25	3/8" x 0	4.78	3.57	14.40	1.95	1.18	6.44	85.8
Belmont Meigs Creek CT-24	3/8" x 0	3.05	1.68	13.38	1.81	0.55	7.86	74.6
Belmont Pittsburgh BM-105	3/8" x 0	3.25	2.06	10.80	1.78	0.49	3.50	27.5
PENNSYLVANIA Greene Pittsburgh BM-20	3/8" x 0	2.62	1.24	8.10	1.83	0.48	5.90	91.5
Greene Senickley BM-43	3/8" x 0	3.49	2.26	11.40	1.68	0.43	4.30	38.0
Greene Pittsburgh BM-53	3/8" x 0	3.43	2.31	10.30	1.94	0.77	4.90	84.5

APPENDIX D

WASHED COAL WITH TOTAL SULFUR - 1.50% TO 2.0%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Washed Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Recovery
PENNSYLVANIA Clarion Lower Kittanning EM-60	3/8" x 0	3.82	2.68	10.5	1.69	0.75	4.90	80.7
Clearfield "E" Seam CT-62	3/8" x 0	3.25	2.10	14.41	1.90	1.04	10.08	89.5
Indiana Lower Kittanning CT-46	3/8" x 0	4.26	2.80	17.35	1.74	0.71	8.64	84.0
Indiana Lower Kittanning CT-1	3/8" x 0	4.80	3.49	13.10	1.87	0.95	4.96	76.8
Indiana Lower Kittanning CT-17	3/8" x 0	5.12	3.77	14.34	1.80	0.95	5.84	83.1
Indiana Lower Kittanning CT-18	3/8" x 0	4.60	3.28	19.10	1.83	0.90	6.86	79.7
Armstrong Kittanning CT-65	3/8" x 0	5.12	3.56	16.36	1.75	0.73	3.72	44.5

The McNally Pittsburg Mfg. Corp.

APPENDIX D

WASHED COAL WITH TOTAL SULFUR - 1.50% TO 2.0%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
PENNSYLVANIA Armstrong Lower Kittanning CT-68	3/8" x 0	3.98	2.88	23.49	1.74	0.89	13.10	81.8
Cambria Upper Freeport CT-47	3/8" x 0	4.56	3.27	18.33	1.78	0.92	8.78	83.3
WEST VIRGINIA Monongalia Pittsburgh BM-21	3/8" x 0	2.48	1.25	8.60	1.80	0.51	6.20	90.6
Grant Town Pittsburgh CT-14	3/8" x 0	2.41	1.22	10.43	1.84	0.60	6.38	94.3
Barbour Pittsburgh BM-85	3/8" x 0	3.87	2.71	9.50	1.65	0.31	3.80	34.0
Barbour Middle Kittanning BM-84	3/8" x 0	3.24	2.68	19.30	1.73	1.07	9.70	78.3

TABLE V, PAGE 1

APPENDIX - E

WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Washed Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Recovery
ILLINOIS Fulton No. 2 CT-39	3/8" x 0	5.60	4.26	21.43	2.27	1.09	3.71	25.9
Franklin No. 6 BM-18	3/8" x 0	2.76	1.16	8.00	2.42	0.84	4.20	72.3
Williamson No. 6 CT-55	3/8" x 0	4.26	2.58	18.53	2.44	0.57	6.36	74.1
Peoria No. 2 CT-34	3/8" x 0	5.33	3.40	13.43	2.45	0.49	2.86	54.9
Saline No. 6 CT-57	3/8" x 0	5.09	3.37	20.90	2.44	0.70	5.08	69.6
INDIANA Sullivan No. 5 CT-31	3/8" x 0	5.47	3.74	19.42	2.29	0.53	4.10	24.0

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WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Washed Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Recovery
IOWA Monroe Mammoth BM-34	3/8" x 0	5.81	4.17	14.50	2.46	1.00	6.40	72.9
KANSAS Cherokee Mineral BM-40	14M x 0	4.12	2.58	13.90	2.39	0.87	7.10	72.0
KENTUCKY Muhlenberg No. 12 BM-71	3/8" x 0	4.25	3.14	18.00	2.39	1.05	8.30	71.9
Muhlenberg No. 12 BM-79	3/8" x 0	4.58	3.30	17.20	2.40	0.96	8.30	76.2
Hopkins No. 9 BM-7	3/8" x 0	4.52	2.83	12.50	2.46	0.52	4.00	48.0
Hopkins No. 14 BM-69	3/8" x 0	4.97	3.70	15.30	2.06	0.79	3.10	45.2

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APPENDIX E

TABLE V, PAGE 3

WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Recovery
KENTUCKY Hopkins No. 9 EM-73	3/8" x 0	4.10	2.44	9.20	2.33	0.59	4.00	51.4
Union No. 6 and No. 9 EM-1	3/8" x 0	4.36	2.86	14.60	2.39	0.80	5.90	77.9
OHIO Coshocton Middle Kittanning EM-41	3/8" x 0	6.18	4.33	13.20	2.19	0.47	2.10	51.9
Coshocton Middle Kittanning CT-26	3/8" x 0	4.30	2.39	10.55	2.46	0.71	3.35	84.3
Coshocton 5-A CT-10	3/8" x 0	4.00	2.68	17.46	2.39	1.20	7.47	82.8
Coshocton Pittsburgh CT-30	3/8" x 0	3.33	1.99	14.05	2.40	1.06	5.36	80.2

APPENDIX E

WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample		Raw Coal Analysis			Washed Coal Analysis			
	Coal Size	Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	Recovery
OHIO Tuscarawas Middle Kittanning CT-45	3/8" x 0	4.99	2.70	12.33	2.36	0.52	3.73	80.1
Tuscarawas Middle Kittanning CT-44	3/8" x 0	5.66	3.48	14.53	2.41	0.53	3.90	78.3
Athens 6,7 and 8 CT-5	3/8" x 0	4.61	2.67	11.17	2.42	0.59	3.17	55.3
Jefferson Pittsburgh BM-58	14M x 0	4.09	3.08	11.90	2.43	1.27	6.10	80.6
Jefferson Pittsburgh BM-57	14M x 0	3.29	1.99	9.60	2.33	0.88	5.00	84.5
Jefferson Pittsburgh CT-27	3/8" x 0	4.59	3.00	21.36	2.08	0.79	4.11	26.7
Harrison Pittsburgh BM-27	3/8" x 0	3.97	2.86	22.90	2.35	0.83	4.20	22.7

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WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
OHIO Harrison Pittsburgh CT-20	3/8" x 0	3.43	1.99	13.01	2.44	0.94	6.36	88.9
Jackson No. 4A CT-35	3/8" x 0	3.87	1.79	10.43	2.46	0.32	2.56	61.7
Gallia Pittsburgh BM-35	3/8" x 0	3.44	2.36	8.90	2.27	1.15	6.30	94.3
Perry Middle Kittanning BM-38	3/8" x 0	4.25	3.18	17.80	2.10	0.99	8.70	81.9
Belmont Meigs Creek CT-24	3/8" x 0	3.05	1.68	13.38	2.28	1.00	11.42	96.6
Belmont Pittsburgh BM-101	3/8" x 0	3.25	2.06	10.80	2.35	1.08	6.00	80.6
PENNSYLVANIA Clarion Lower Clarion CT-50	14M x 0	9.51	6.92	18.06	2.08	0.56	3.63	45.9

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WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
PENNSYLVANIA Clarion Clarion BM-48	14M x 0	4.28	2.64	10.30	2.44	0.80	5.10	78.5
Green Sewickley BM-43	3/8" x 0	3.49	2.26	11.40	2.32	1.13	8.80	93.9
Armstrons Kittanning CT-65	14M x 0	5.26	3.60	16.42	2.47	1.29	6.69	80.9
TENNESSEE Anderson Dean BM-30	3/8" x 0	3.61	2.02	9.20	2.26	0.59	5.60	84.6
VIRGINIA Harrison Pittsburgh BM-88	14M x 0	6.32	4.69	11.70	2.20	0.63	5.00	79.3
Harrison Pittsburgh BM-85	14M x 0	3.96	2.69	9.30	2.05	0.77	5.80	91.7

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APPENDIX E

WASHED COAL WITH TOTAL SULFUR - 2.0% TO 2.50%

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
VIRGINIA Marion Pittsburgh BM-25	3/8" x 0	3.83	2.42	11.00	2.17	0.74	6.00	90.6
Marion Pittsburgh BM-28	3/8" x 0	2.69	0.96	6.80	2.41	0.67	5.90	97.8
Monongalia Sewickley BM-87	3/8" x 0	4.77	3.05	14.70	2.35	0.34	4.00	30.4
Ohio Pittsburgh BM-54	14M x 0	3.60	2.24	9.30	2.22	0.74	4.40	83.8
Ohio Pittsburgh BM-56	14M x 0	3.96	2.50	10.90	2.17	0.71	4.60	78.1
WEST VIRGINIA Marshall Pittsburgh BM-24	14M x 0	4.13	2.40	12.90	2.24	0.42	3.20	45.0

APPENDIX - F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
ILLINOIS Fulton No. 2 CT-39	3/8" x 0	5.60	4.26	21.43	2.80	1.50	4.94	69.2
Fulton No. 6 BM-2	3/8" x 0	3.20	1.16	10.20	2.56	0.43	6.20	42.2
Fulton No. 5 CT-61	3/8" x 0	4.05	2.29	20.69	2.59	0.58	6.79	32.0
Fulton No. 5 BM-63	3/8" x 0	3.45	1.29	10.30	2.68	0.47	6.70	63.6
Fulton No. 5 BM-61	3/8" x 0	3.77	1.79	12.90	2.69	0.48	6.40	51.4
Knox No. 6 BM-11	3/8" x 0	3.02	1.[illegible]	8.60	2.64	0.73	4.20	35.3

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TABLE VI, PAGE 2

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
ILLINOIS								
Knox No. 5 CT-53	3/8" x 0	7.93	5.78	20.90	2.94	1.09	3.75	42.2
Montgomery No. 6 BM-8	3/8" x 0	4.16	1.50	11.00	3.85	1.26	6.10	38.6
Montgomery No. 2 CT-37	3/8" x 0	4.98	2.90	16.94	2.87	0.49	3.37	16.5
Christian No. 6 BM-12	3/8" x 0	4.71	2.44	19.00	3.27	0.61	4.80	27.1
St. Clair No. 6 BM-9	3/8" x 0	3.47	1.34	10.60	2.71	0.54	3.90	37.4
Franklin No. 6 BM-18	3/8" x 0	2.76	1.16	8.00	2.52	0.88	5.80	90.7
Macoupin No. 6 BM-64	3/8" x 0	5.78	2.73	13.00	3.89	0.42	4.00	47.4

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TABLE VI, PAGE 3

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State	County	Seam	Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
ILLINOIS	Williamson	No. 6	CT-55	3/8" x 0	4.26	2.58	18.53	2.63	0.82	9.54	86.8
	Perry	No. 6	BM-66	3/8" x 0	4.28	2.61	17.00	2.58	0.50	3.30	46.4
	Perry	No. 5	CT-38	3/8" x 0	4.54	2.48	15.60	2.66	0.37	2.80	27.8
	Randolph	No. 5	BM-65	3/8" x 0	5.65	3.34	13.00	2.98	0.42	3.90	46.4
	Peoria	No. 2	CT-34	3/8" x 0	5.33	3.40	13.43	2.79	0.77	3.78	83.5
	Saline	No. 6	CT-57	3/8" x 0	5.09	3.37	20.90	2.68	0.99	8.76	82.7
INDIANA	Warrick	No. 6	BM-5	3/8" x 0	3.78	2.36	11.50	2.55	1.11	4.20	35.4

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TABLE VI, PAGE 4

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	 Pyritic Sulfur	 Ash	Washed Coal Analysis Totel Sulfur	 Pyritic Sulfur	 Ash	Recovery
INDIANA Pike No. 5 BM-17	3/8" x 0	3.19	1.48	8.70	2.69	0.88	5.20	60.9
Pike No. 5 BM-15	3/8" x 0	3.20	0.94	7.90	2.82	0.50	5.10	74.8
Clay No. 3 BM-14	3/8" x 0	4.50	1.62	11.40	3.85	0.81	4.80	54.1
Sullivan No. 5 CT-31	3/8" x 0	5.47	3.74	19.42	2.59	0.84	5.68	60.8
IOWA Marion Des Moines Bed BM-32	3/8" x 0	12.20	10.60	23.90	4.03	1.92	5.40	15.8
Marion Des Moines Bed BM-62	3/8" x 0	10.30	7.12	26.50	5.92	1.96	6.10	17.3
Monroe Mammoth BM-34	3/8" x 0	5.81	4.17	14.50	2.90	1.33	7.80	85.0

APPENDIX F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
KANSAS								
Cherokee **Fleming Bed** **BM-33**	3/8" x 0	5.17	3.70	15.60	2.75	1.08	4.30	60.2
Cherokee **Mineral Bed** **BM-40**	3/8" x 0	3.92	2.44	13.00	2.79	1.31	8.30	85.3
KENTUCKY								
Muhlenberg No. 11 and 12 **BM-4**	3/8" x 0	3.50	1.51	8.70	2,76	0.74	4.70	71.1
Muhlenberg **No. 11** **BM-75**	3/8" x 0	5.05	3.01	12.80	2.69	0.43	3.30	66.9
Muhlenberg **No. 12** **BM-72**	3/8" x 0	4.26	2.66	18.90	2.68	0.76	4.90	30.2
Muhlenberg **No. 11** **BM-76**	3/8" x 0	4.88	3.13	13.80	2.59	0.49	3.10	59.4

APPENDIX F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
KENTUCKY								
Muhlenberg No. 11 BM-74	3/8" x 0	4.75	2.68	13.00	3.09	0.65	3.40	52.6
Muhlenberg No. 11 BM-78	3/8" x 0	4.52	2.64	12.60	2.79	0.64	3.40	66.9
Muhlenberg No. 11 BM-10	3/8" x 0	2.96	0.97	5.20	2.56	0.54	3.30	82.8
Muhlenberg No. 12 BM-71	3/8" x 0	4.25	3.14	18.00	2.63	1.29	10.10	83.3
Hopkins No. 9 BM-7	3/8" x 0	4.52	2.83	12.50	2.82	0.90	6.40	81.4
Hopkins No. 14 BM-69	3/8" x 0	4.97	3.70	15.30	2.73	1.44	5.50	72.4
Hopkins No. 9 BM-73	3/8" x 0	4.10	2.44	9.20	2.66	0.96	6.50	89.6

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COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
KENTUCKY Hopkins No. 11 BM-80	3/8" x 0	4.28	2.37	11.80	2.87	0.64	3.10	64.0
Hopkins No. 12 BM-82	3/8" x 0	4.30	2.16	17.80	2.99	0.56	3.40	24.8
Ohio No. 9 BM-6	3/8" x 0	4.40	1.74	11.60	2.68	0.56	4.00	61.2
Union No. 6 & 9 BM-1	3/8" x 0	4.36	2.86	14.60	2.61	1.05	7.20	86.1
MISSOURI Henry Tebo BM-13	3/8" x 0	5.35	2.97	20.00	3.10	0.54	6.00	42.2
OHIO Belmont Pittsburgh BM-3	3/8" x 0	4.12	2.48	14.70	2.67	0.77	4.60	44.6

APPENDIX F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Washed Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Recovery
OHIO								
Belmont Pittsburgh CT-6	3/8" x 0	4.59	2.59	29.09	2.77	0.42	3.47	23.0
Belmont Pittsburgh BM-22	3/8" x 0	5.69	3.88	13.9	2.82	0.79	4.50	37.5
Belmont Pittsburgh BM-89	3/8" x 0	5.07	3.18	11.20	2.67	0.62	3.60	22.0
Belmont Pittsburgh BM-90	3/8" x 0	4.40	2.55	11.30	2.69	0.60	3.70	41.7
Harrison Pittsburgh BM-27	3/8" x 0	3.97	2.86	22.90	3.14	1.74	6.90	64.6
Morgan Meigs Creek CT-12	3/8" x 0	5.4	2.84	20.90	3.75	0.57	4.70	22.7
Morgan Meigs Creek BM-36	3/8" x 0	5.57	2.75	12.90	3.99	0.68	3.70	34.2

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COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis			Washed Coal Analysis			Recovery
		Total Sulfur	Pyritic Sulfur	Ash	Total Sulfur	Pyritic Sulfur	Ash	
OHIO Noble Meigs Creek BM-37	3/8" x 0	5.80	2.78	14.10	4.13	0.53	3.40	8.8
Noble Meigs Creek BM-97	3/8" x 0	5.38	3.37	20.90	2.91	0.29	4.90	4.5
Noble Meigs Creek BM-98	3/8" x 0	6.14	3.10	13.10	4.26	0.53	3.80	8.6
Jackson No. 4A CT-35	3/8" x 0	3.87	1.79	10.43	2.64	0.58	3.37	84.4
Coshocton No. 6 BM-41	3/8" x 0	6.18	4.33	13.20	2.75	0.95	3.20	75.1
Coshocton No. 6 CT-26	3/8" x 0	4.30	2.39	10.55	2.63	0.89	4.21	90.3

APPENDIX F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Washed Coal Analysis Total Sulfur	Pyritic Sulfur	Ash	Recovery
OHIO								
Tuscarawas No. 6 CT-45	3/8" x 0	4.99	2.70	12.33	2.84	0.96	5.92	89.8
Tuscarawas No. 6 CT-44	3/8" x 0	5.66	3.48	14.53	2.68	0.82	5.76	86.6
Gurnsey No. 7A CT-48	3/8" x 0	4.53	3.10	28.69	2.78	0.77	3.81	39.5
Athens Beds 6, 7 & 8 CT-5	3/8" x 0	4.61	2.67	11.17	2.92	0.98	4.37	81.2
Jefferson Pittsburgh BM-59	3/8" x 0	4.23	3.19	12.30	2.96	1.87	7.10	79.8
Jefferson Pittsburgh BM-57	3/8" x 0	3.27	1.96	10.30	2.90	1.53	6.70	93.5
Jefferson Pittsburgh CT-27	3/8" x 0	4.59	3.00	21.36	2.83	1.36	6.86	60.2

The McNally Pittsburg Mfg. Corp.

APPENDIX F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
PENNSYLVANIA Clarion Lower Clarion CT-50	14M x 0	9.51	6.92	18.06	2.81	0.99	5.20	67.1
Clarion Clarion BM-48	3/8" x 0	4.36	2.80	11.00	2.89	1.20	6.30	79.0
Clearfield Middle Kittanning CT-42	3/8" x 0	9.29	6.80	23.18	3.81	2.19	8.60	44.8
TENNESSEE Anderson Dean BM-30	3/8" x 0	3.61	2.02	9.20	2.52	0.89	6.90	94.0
WEST VIRGINIA Monongalia Pittsburgh BM-26	3/8" x 0	3.90	1.70	11.00	2.65	0.35	4.70	57.9
Monongalia Sewickley BM-87	3/8" x 0	4.77	3.05	14.70	2.78	0.82	7.00	72.9

The McNally Pittsburg Mfg. Corp.

APPENDIX F

COAL WHICH CANNOT BE WASHED TO LESS THAN 2.50% TOTAL SULFUR

State County Seam Sample	Coal Size	Raw Coal Analysis Total Sulfur	Raw Coal Analysis Pyritic Sulfur	Raw Coal Analysis Ash	Washed Coal Analysis Total Sulfur	Washed Coal Analysis Pyritic Sulfur	Washed Coal Analysis Ash	Recovery
WEST VIRGINIA Marshall Pittsburgh BM-55	3/8" x 0	4.83	1.98	9.10	3.56	0.38	3.50	50.7
Ohio Pittsburgh BM-42	3/8" x 0	4.03	2.64	34.50	2.49	0.48	3.80	23.2
Ohio Pittsburgh BM-54	3/8" x 0	3.50	2.13	9.10	2.98	1.55	6.40	93.7
Ohio Pittsburgh BM-56	3/8" x 0	3.82	2.32	10.50	2.90	1.37	6.30	90.3
Marshall Pittsburgh BM-24	14M x 0	4.13	2.40	12.90	2.87	0.85	5.60	77.9
Harrison Pittsburgh BM-86	3/8" x 0	5.05	2.64	9.10	2.99	0.41	4.00	30.2
Harrison Pittsburgh BM-88	3/8" x 0	6.57	4.93	11.50	2.78	1.20	6.20	79.1

The McNally Pittsburg Mfg. Corp.

APPENDIX - G

RANKING OF COAL

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
ALABAMA			
Walker			
America			
BM-91	1.40	$1B_2$	
	1.60	$1A_3$	
	1.60	$2A_3$	
	1.30	$3C_1$	
	1.60	$3A_2$	
Walker			
Clements			
BM-92	1.30	$1C_2$	
	1.30	$2C_2$	
	1.30	$3C_2$	
	1.40	$3B_3$	
Anderson			
Mary Lee			
BM-93	1.60	$1A_1$	
	1.60	$2A_1$	
	1.60	$3A_1$	
Anderson			
Mary Lee			
BM-94	1.40	$1A_1$	
	1.60	$1A_2$	
	1.40	$2A_1$	
	1.60	$2A_2$	
	1.40	$3A_1$	
	1.60	$3A_2$	
Anderson			
Gwin			
BM-95	1.60	$1A_2$	
	1.60	$2A_2$	
	1.60	$3A_2$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
ILLINOIS			
Peoria			
No. 2			
CT-34	1.30	$1B_5$	
	1.30	$2B_4$	
	1.30	$3B_4$	
Perry			
No. 5			
CT-38	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Perry			
No. 6			
BM-66	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Fulton			
No. 2			
CT-39	1.30	$1C_5$	
	1.30	$2C_4$	
	1.30	$3B_4$	
Fulton			
No. 5			
CT-61	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Fulton			
No. 5			
BM-63	1.30	$1B_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
ILLINOIS Fulton No. 5 BM-61	1.30	$1B_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	
Fulton No. 5 BM-2	1.30	$1B_5$	
	1.30	$2C_5$	
	1.30	$3B_5$	
Saline No. 5 CT-56	1.30	$1C_3$	
	1.40	$1B_2$	
	1.90	$1C_2$	
	1.30	$2C_3$	
	1.60	$2B_2$	
	1.90	$2C_2$	
	1.30	$3C_3$	
	1.60	$3B_2$	
	1.90	$3C_2$	
Saline No. 6 CT-57	1.30	$1C_3$	
	1.40	$2C_3$	
	1.40	$3C_3$	
Christian No. 6 BM-12	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Williamson No. 6 CT-55	1.40	$1C_3$	
	1.40	$2C_3$	
	1.40	$3C_3$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
ILLINOIS			
Williamson			
No. 6			
BM-77	1.40	$1B_2$	
	1.60	$1C_2$	
	1.60	$2A_3$	
	1.60	$3B_2$	
St. Clair			
No. 6			
BM-9	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Montgomery			
No. 2			
CT-37	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Montgomery			
No. 6			
BM-8	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Franklin			
No. 5			
CT-54	1.30	$1C_3$	
	1.90	$1A_4$	
	1.40	$2A_3$	
	1.90	$2A_4$	
	1.40	$3A_3$	
	1.90	$3A_4$	
Franklin			
No. 6			
BM-18	1.30	$1B_4$	
	1.30	$2B_4$	
	1.30	$3B_4$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
ILLINOIS			
Franklin			
No. 6			
CT-60	1.40	$1A_1$	
	1.90	$1A_2$	
	1.90	$2A_1$	
	1.90	$3A_1$	
Macoupin			
No. 6			
BM-64	1.30	$1B_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Randolph			
No. 5			
BM-65	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Jefferson			
No. 6			
CT-58	1.90	$1A_2$	
	1.90	$2A_2$	
	1.90	$3A_2$	
Jefferson			
No. 6			
BM-16	1.90	$1A_2$	
	1.90	$2A_2$	
	1.90	$3A_2$	
Jefferson			
No. 6			
CT-59	1.60	$1B_2$	
	1.90	$1C_2$	
	1.30	$2C_1$	
	1.90	$2A_3$	
	1.40	$3B_1$	
	1.90	$3A_3$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
ILLINOIS			
Knox			
No. 6			
CT-53	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Knox			
No. 6			
BM-11	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
INDIANA			
Sullivan			
No. 5			
CT-31	1.30	$1C_4$	
	1.30	$2C_4$	
	1.40	$3B_4$	
Sullivan			
No. 7			
CT-70	1.60	$1A_2$	
	1.60	$2A_2$	
	1.60	$3A_2$	
Sullivan			
No. 6			
BM-68	1.60	$1A_3$	
	1.40	$2A_3$	
	1.60	$2A_4$	
	1.60	$3A_3$	
Warrick			
No. 6			
BM-5	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
INDIANA Vigo No. 7 BM-67	1.60	$1A_1$	
	1.60	$2A_1$	
	1.60	$3A_1$	
Indiana No. 3 BM-14	1.30	$1C_5$	
	1.30	$2B_5$	
	1.30	$3C_5$	
Pike No. 5 BM-15	1.30	$1B_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	
Pike No. 5 BM-17	1.30	$1B_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	
IOWA Mabaska Lower Cherokee BM-31	1.60	$1A_2$	
	1.60	$2A_2$	
	1.60	$3A_1$	
Monroe Mammoth BM-34	1.30	$1B_4$	
	1.40	$2B_4$	
	1.30	$3C_3$	
	1.40	$3B_4$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
IOWA			
Marion			
Des Moines #1			
BM-32	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Marion			
BM-62	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Cherokee			
Fleming			
BM-33	1.30	$1C_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	
Cherokee			
Mineral			
BM-40	1.30	$1C_4$	
	1.30	$2C_4$	
	1.40	$3B_4$	
KENTUCKY			
Hopkin			
No. 6			
CT-36	1.30	$1B_2$	0.63
	1.90	$1A_3$	
	1.30	$2C_2$	
	1.90	$2A_3$	
	1.60	$3A_2$	
	1.90	$3A_3$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
KENTUCKY Hopkin No. 9 BM-7	1.30	$1C_4$	8.02
	1.30	$2C_4$	
	1.30	$3C_5$	
Hopkin No. 14 BM-69	1.30	$1C_4$	0.16
	1.30	$2C_4$	
	1.30	$3B_3$	
	1.40	$3B_4$	
Hopkin No. 9 BM-73	1.30	$1C_4$	8.02
	1.30	$2B_4$	
	1.40	$3B_4$	
Hopkin No. 11 BM-80	1.30	$1B_5$	1.73
	1.30	$2B_5$	
	1.30	$3B_5$	
Hopkin No. 12 BM-82	1.30	$1C_5$	1.18
	1.30	$2C_5$	
	1.30	$3C_5$	
Muehlenburg No. 12 BM-79	1.30	$1C_3$	1.18
	1.40	$1B_4$	
	1.30	$2C_3$	
	1.40	$2A_4$	
	1.30	$3C_3$	
	1.40	$3C_3$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
KENTUCKY			
Muehlenburg			
No. 12			
BM-81	1.30	$1C_3$	1.18
	1.60	$1A_4$	
	1.30	$2C_2$	
	1.40	$2A_3$	
	1.60	$2A_4$	
	1.30	$3C_1$	
	1.60	$3A_3$	
Muehlenburg			
No. 12			
BM-71	1.30	$1C_3$	1.18
	1.40	$1B_4$	
	1.30	$2C_3$	
	1.40	$2B_4$	
	1.30	$3C_3$	
	1.40	$3B_4$	
Muehlenburg			
No. 11 & 12			
BM-4	1.30	$1B_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	
Muehlenburg			
No. 11			
BM-10	1.30	$1B_5$	1.73
	1.30	$2B_5$	
	1.30	$3B_5$	
Muehlenburg			
No. 12			
BM-72	1.30	$1C_5$	1.18
	1.30	$2C_5$	
	1.30	$3C_5$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
KENTUCKY			
Muehlenburg			
No. 11			
BM-74	1.30	$1B_5$	1.73
	1.30	$2B_5$	
	1.30	$3B_5$	
Muehlenburg			
No. 11			
BM-75	1.30	$1B_5$	1.73
	1.30	$2B_5$	
	1.30	$3B_5$	
Muehlenburg			
No. 11			
BM-76	1.30	$1B_5$	1.73
	1.30	$2B_5$	
	1.30	$3B_5$	
Muehlenburg			
No. 11			
BM-78	1.30	$1B_5$	1.73
	1.30	$2B_5$	
	1.30	$3B_5$	
Union			
No. 6 & 9			
BM-1	1.30	$1C_3$	
	1.40	$1A_4$	
	1.40	$2A_4$	
	1.40	$3A_4$	
Ohio			
No. 6 & 9			
BM-6	1.30	$1B_5$	
	1.30	$2B_5$	
	1.30	$3B_5$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
MARYLAND			
Allegheny			
Lower Bakerstown			
BM-104	1.30	$1C_2$	
	1.60	$1A_3$	
	1.30	$2C_2$	
	1.60	$2A_3$	
	1.40	$3C_2$	
	1.60	$3B_3$	
Allegheny			
U. Freeport			
BM-106	1.30	$1C_2$	
	1.60	$1A_4$	
	1.30	$2C_2$	
	1.40	$2B_3$	
	1.60	$2A_4$	
	1.30	$2C_2$	
	1.60	$3A_3$	
MISSOURI			
Henry			
Tebo			
BM-13	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
OHIO			
Mahoning			
Brookville			
CT-11	1.40	$1A_2$	0.44
	1.90	$1A_4$	
	1.30	$2B_1$	
	1.60	$2A_2$	
	1.90	$2A_3$	
	1.40	$3A_1$	
	1.90	$3A_2$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO			
Jackson			
No. 4A			
CT-35	1.30	$1B_5$	0.71
	1.30	$2B_4$	
	1.30	$3B_4$	
Harrison			
No. 6A			
CT-8	1.30	$1B_2$	2.44
	1.60	$1A_3$	
	1.40	$2A_2$	
	1.90	$2A_3$	
	1.90	$3A_2$	
Harrison			
No. 6A			
CT-9	1.30	$1B_2$	2.44
	1.90	$1A_3$	
	1.30	$2B_1$	
	1.90	$2A_2$	
	1.40	$3A_1$	
	1.90	$3A_2$	
Harrison			
Pittsburg			
CT-20	1.30	$1C_3$	5.55
	1.40	$1B_4$	
	1.30	$2B_3$	
	1.60	$2A_4$	
	1.40	$3A_3$	
	1.90	$3A_4$	
Harrison			
No. 9			
BM-23	1.30	$1C_2$	4.02
	1.60	$1A_3$	
	1.40	$2A_2$	
	1.60	$2A_3$	
	1.60	$3A_2$	

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO Harrison Pitt. BM-27	1.30	$1C_4$	5.55
	1.30	$2C_4$	
	1.30	$3C_4$	
Harrison No. 9 BM-29	1.60	$1A_2$	
	1.60	$2A_2$	
	1.60	$3A_2$	
Lawrence No. 5 CT-25	1.30	$1C_2$	9.91
	1.30	$2B_2$	
	1.60	$2A_3$	
	1.90	$2A_4$	
	1.30	$3C_1$	
	1.60	$3B_2$	
	1.90	$3A_3$	
Muskingum No. 5 CT-43	1.30	$1C_3$	9.91
	1.30	$2B_1$	
	1.40	$2A_2$	
	1.90	$2A_3$	
	1.30	$3C_1$	
	1.60	$3A_2$	
	1.90	$3A_3$	
Muskingum No. 6 CT-52	1.30	$1A_3$	9.78
	1.90	$1A_4$	
	1.30	$2A_3$	
	1.90	$2A_4$	
	1.40	$3A_3$	
	1.90	$3A_4$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO Athens No. 6,7, &8 CT-5	1.30	$1C_5$	
	1.30	$2B_4$	
	1.30	$3C_4$	
Jefferson No. 5 CT-10	1.30	$1C_3$	9.91
	1.40	$1B_4$	
	1.30	$2C_2$	
	1.40	$2B_3$	
	1.60	$2A_4$	
	1.30	$3C_2$	
	1.40	$3B_3$	
	1.90	$3A_4$	
Jefferson Pitt. CT-27	1.30	$1C_4$	5.55
	1.30	$2C_4$	
	1.30	$3C_3$	
Jefferson Pitt. CT-30	1.30	$1C_3$	5.55
	1.30	$2C_3$	
	1.40	$2A_4$	
	1.30	$3C_3$	
	1.60	$3A_4$	
Jefferson No. 7A CT-40	1.40	$1A_1$	0.28
	1.90	$1A_2$	
	1.90	$2A_1$	
	1.90	$3A_1$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO Jefferson Pitt. BM-57	1.30	$1C_4$	5.55
	1.30	$2C_3$	
	1.30	$3C_3$	
	1.40	$3A_4$	
Jefferson Pitt. BM -58	1.30	$1C_3$	5.55
	1.60	$1A_4$	
	1.40	$2A_3$	
	1.60	$2A_4$	
	1.30	$3B_2$	
	1.60	$3A_3$	
Jefferson Pitt. BM-59	1.30	$1C_4$	5.55
	1.30	$2C_4$	
	1.30	$3C_3$	
	1.40	$3A_4$	
Belmont Pitt. CT-6	1.30	$1C_5$	5.55
	1.30	$2C_5$	
	1.30	$3C_5$	
Belmont Pitt. BM-3	1.30	$1C_5$	5.55
	1.30	$2C_5$	
	1.30	$3C_5$	
Belmont Pitt. BM-22	1.30	$1C_5$	5.55
	1.30	$2C_5$	
	1.30	$3C_5$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO Belmont Pitt. BM-89	1.30	$1C_5$	5.55
	1.30	$2C_5$	
	1.30	$3C_5$	
Belmont Pitt. BM-90	1.30	$1C_5$	5.55
	1.30	$2C_5$	
	1.30	$3C_5$	
Belmont No. 9 CT-24	1.30	$1C_3$	4.02
	1.60	$1A_4$	
	1.40	$2B_3$	
	1.90	$2A_4$	
	1.40	$3B_3$	
	1.90	$3A_4$	
Belmont Pitt. BM-105	1.30	$1C_3$	5.55
	1.40	$1A_4$	
	1.30	$2C_3$	
	1.40	$2A_4$	
	1.30	$3C_3$	
	1.60	$3A_4$	
Columbiana No. 6 CT-7	1.30	$1B_2$	9.78
	1.60	$1A_3$	
	1.90	$1A_4$	
	1.40	$2A_1$	
	1.90	$2A_2$	
	1.60	$3A_1$	
	1.90	$3A_2$	

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State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO			
Columbiana			
No. 6			
CT-41	1.40	$1A_1$	9.78
	1.90	$1A_2$	
	1.90	$2A_1$	
	1.90	$3A_1$	
Coshocton			
No. 6			
CT-26	1.30	$1B_4$	9.78
	1.40	$2A_4$	
	1.40	$3A_4$	
Guernsey			
No. 7A			
CT-48	1.30	$1C_5$	
	1.30	$2C_5$	
	1.30	$3C_5$	
Morgan			
No. 9			
CT-12	1.30	$1C_5$	4.02
	1.30	$2C_5$	
	1.30	$3C_5$	
Tuscarawas			
No. 6			
CT-44	1.40	$1C_2$	9.78
	1.40	$2C_2$	
	1.40	$3C_2$	
Tuscarawas			
No. 6			
CT-45	1.40	$1C_2$	9.78
	1.40	$2C_2$	
	1.40	$3C_3$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
OHIO Perry No. 6 C-13	1.30	$1C_3$	9.78
	1.60	$1C_2$	
	1.40	$2C_3$	
	1.90	$2C_2$	
	1.40	$3C_3$	
	1.90	$3C_2$	
Galia Pitt. BM-35	1.30	$1C_3$	5.55
	1.30	$2C_3$	
	1.60	$2C_2$	
	1.60	$3C_2$	
Noble Meigs Creek BM-97	1.30	$1C_5$	4.02
	1.30	$2C_5$	
	1.30	$3C_5$	
Noble Meigs Creek BM-98	1.30	$1C_5$	4.02
	1.30	$2C_5$	
	1.30	$3C_5$	
Noble Meigs Creek BM-37	1.30	$1C_5$	4.02
	1.30	$2C_5$	
	1.30	$3C_5$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA Indiana L. Kitt. CT-1			
	1.30	$1C_3$	
	1.40	$1A_4$	
	1.40	$2A_3$	
	1.90	$2A_4$	
	1.30	$3C_2$	
	1.40	$3A_3$	
	1.90	$3A_4$	
Indiana L. Kitt. CT-17			
	1.30	$1C_2$	
	1.40	$1A_3$	
	1.60	$1A_4$	
	1.30	$2C_2$	
	1.60	$2A_3$	
	1.90	$2A_4$	
	1.30	$3C_2$	
	1.60	$3A_3$	
	1.90	$3A_4$	
Indiana L. Kitt. CT-18			
	1.30	$1C_2$	
	1.40	$1B_3$	
	1.90	$1A_4$	
	1.40	$2B_2$	
	1.90	$2A_3$	
	1.40	$3B_2$	
	1.90	$3B_3$	
Indiana U. Freeport CT-19			
	1.30	$1C_1$	
	1.90	$1A_2$	
	1.60	$2A_1$	
	1.90	$2A_2$	
	1.90	$3A_1$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA Indiana L. Freeport CT-67	1.60	$1A_2$	
	1.90	$1A_3$	
	1.60	$2A_1$	
	1.90	$2A_2$	
	1.90	$3A_1$	
Indiana No. B CT-70	1.30	$1B_2$	
	1.60	$1A_3$	
	1.90	$1A_4$	
	1.60	$2A_2$	
	1.90	$2A_3$	
	1.60	$3A_2$	
	1.90	$3A_3$	
Indiana L. Kitt. BM-46	1.30	$1B_2$	
	1.60	$1A_3$	
	1.40	$2A_2$	
	1.60	$2A_3$	
	1.60	$3A_2$	
Indiana L. Kitt. BM-47	1.40	$1B_2$	
	1.60	$1B_3$	
	1.60	$2B_2$	
	1.60	$3B_2$	
Indiana L. Kitt. CT-46	1.30	$1B_2$	
	1.60	$1A_3$	
	1.90	$1A_4$	
	1.40	$2B_2$	
	1.90	$2A_3$	
	1.40	$3B_2$	
	1.90	$3A_3$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA			
Tioga			
U. Freeport			
BM-51	1.60	$1A_1$	
	1.60	$2A_1$	
	1.60	$3A_1$	
Bedford			
L. Kitt.			
BM-52	1.40	$1A_1$	
	1.60	$1A_2$	
	1.60	$2A_1$	
	1.60	$3A_1$	
Cambria			
L. Kitt &			
L. Freeport			
CT-2	1.30	$1B_1$	
	1.90	$1A_2$	
	1.40	$2A_1$	
	1.90	$2A_2$	
	1.60	$3A_1$	
	1.90	$3A_2$	
Cambria			
L. Kitt.			
CT-3	1.90	$1A_1$	
	1.90	$2A_1$	
	1.90	$3A_1$	
Cambria			
L. Kitt.			
CT-16	1.90	$1A_1$	
	1.90	$2A_1$	
	1.90	$3A_1$	
Cambria			
U. Freeport			
CT-47	1.30	$1C_2$	
	1.40	$1B_3$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA			
Cambria			
U. Freeport			
CT-47	1.60	$1A_4$	
	1.40	$2B_2$	
	1.90	$2A_3$	
	60	$2A_2$	
	.90	$2A_3$	
Cambria			
U. Kitt.			
CT-49	1.90	$1B_1$	
	1.90	$2B_1$	
	1.90	$3B_1$	
Westmoreland			
U. Fr.			
CT-15	1.40	$1B_2$	
	1.60	$1B_3$	
	1.90	$1A_4$	
	1.30	$2B_1$	
	1.60	$2B_2$	
	1.90	$2A_3$	
	1.40	$3B_1$	
	1.90	$3A_2$	
Somerset			
'C' Prime			
CT-4	1.40	$1A_1$	
	1.90	$1A_2$	
	1.90	$2A_1$	
	1.90	$3A_1$	
Allegheny			
D. Fr.			
CT-28	1.30	$1C_1$	
	1.40	$1B_2$	
	1.90	$1A_3$	
	1.60	$2B_1$	
	1.90	$2A_2$	
	1.90	$3A_1$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA Butler U. Fr. BM-96	1.30	$1C_1$	
	1.60	$1A_2$	
	1.60	$2A_1$	
	1.60	$2A_1$	
Green Pitt. BM-20	1.60	$1A_3$	
	1.60	$2A_3$	
	1.30	$3B_2$	
	1.60	$3A_3$	
Green Sewickley BM-43	1.30	$1C_3$	
	1.40	$2A_4$	
	1.60	$3A_5$	
	1.30	$1C_3$	
	1.60	$2A_4$	
	1.30	$1C_2$	
	1.40	$2A_3$	
	1.60	$3A_4$	
Green Pitt, BM-53	1.30	$1B_3$	
	1.40	$1A_4$	
	1.40	$2A_3$	
	1.60	$2A_4$	
	1.60	$3A_3$	
Armstrong U. Fr. CT-29	1.30	$1C_1$	
	1.90	$1A_2$	
	1.60	$2A_1$	
	1.90	$2A_2$	
	1.90	$3A_1$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA Armstrong D. Fr. CT-32	1.30	$1C_1$	
	1.60	$1B_2$	
	1.90	$1A_3$	
	1.30	$2C_1$	
	1.90	$2A_2$	
	1.90	$3A_1$	
Armstrong L. Fr. CT-33	1.30	$1C_2$	
	1.90	$1A_3$	
	1.30	$2C_1$	
	1.90	$2A_2$	
	1.40	$3A_1$	
	1.90	$3A_2$	
Armstrong Kitt. CT-65	1.30	$1C_3$	
	1.30	$2C_3$	
	1.40	$2B_4$	
	1.30	$3C_2$	
	1.60	$3A_4$	
Armstrong U. Fr. CT-66	1.60	$1A_2$	
	1.90	$1A_3$	
	1.40	$2A_1$	
	1.90	$2A_2$	
	1.60	$3A_1$	
	1.90	$3A_2$	
Armstrong L. Kitt. CT-68	1.30	$1C_2$	
	1.60	$1B_3$	
	1.90	$1A_4$	
	1.40	$2B_2$	
	1.90	$2A_3$	
	1.60	$3B_2$	
	1.90	$3A_3$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billions
PENNSYLVANIA Armstrong U. Fr. CT-69	1.40	$1B_2$	
	1.90	$1A_3$	
	1.30	$2B_1$	
	1.60	$2A_2$	
	1.90	$2A_3$	
	1.30	$3B_1$	
	1.90	$3A_2$	
Clearfield M. Kitt CT-42	1.30	$1C_4$	
	1.30	$2C_4$	
	1.30	$3C_4$	
Clearfield No. D CT-51	1.40	$1A_2$	
	1.90	$1A_3$	
	1.30	$2B_1$	
	1.90	$2A_2$	
	1.40	$3A_1$	
	1.90	$3A_2$	
Clearfield No. E CT-62	1.40	$1B_3$	
	1.60	$1A_4$	
	1.30	$2C_2$	
	1.60	$2A_3$	
	1.90	$2A_4$	
	1.60	$3A_2$	
	1.90	$3A_3$	
Clarion L. Clarion CT-50	1.30	$1C_5$	
	1.30	$2C_4$	
	1.30	$3C_4$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA			
Clarion			
M. Kitt			
CT-63	1.90	$1A_1$	
	1.90	$2A_1$	
	1.90	$3A_1$	
Clarion			
U. Clarion			
CT-64	1.30	$1B_1$	
	1.90	$1A_2$	
	1.30	$2B_1$	
	1.90	$2A_2$	
	1.40	$3A_1$	
	1.90	$3A_2$	
Clarion			
Clarion			
BM-48	1.30	$1C_4$	
	1.30	$2C_4$	
	1.30	$3B_3$	
	1.40	$3A_4$	
Clarion			
L. Kitt.			
BM-60	1.30	$1B_2$	
	1.40	$1A_3$	
	1.60	$1A_4$	
	1.30	$2B_2$	
	1.40	$2A_3$	
	1.60	$2A_4$	
	1.40	$3A_2$	
	1.60	$3A_3$	
Jefferson			
L. Kitt.			
BM-49	1.30	$1C_1$	
	1.60	$1A_2$	
	1.30	$2B_1$	
	1.60	$2A_2$	
	1.40	$3A_1$	
	1.60	$3A_2$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
PENNSYLVANIA			
Lawrence			
Brookville			
BM-50	1.30	$1A_1$	
	1.40	$1A_2$	
	1.60	$1A_3$	
	1.40	$2A_1$	
	1.60	$2A_2$	
	1.60	$3A_1$	
Washington			
Pitt.			
BM-39	1.30	$1B_1$	
	1.60	$1A_2$	
	1.30	$2B_1$	
	1.60	$2A_2$	
	1.60	$3A_2$	
Washington			
Pitt.			
BM-44	1.60	$1A_2$	
	1.60	$2A_2$	
	1.30	$3B_1$	
	1.60	$3A_2$	
Anderson	1.30	$1C_4$	
Dean	1.30	$2C_4$	
BM-30	1.30	$3C_3$	
WEST VIRGINIA			
Grant			
Freeport			
CT-22	1.30	$1C_1$	3.50
	1.40	$1C_2$	
	1.90	$1B_3$	
	1.30	$1C_1$	
	1.90	$2B_2$	
	1.40	$3C_1$	
	1.90	$3B_2$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
WEST VIRGINIA			
Grant			
Bakerstown			
CT-23	1.30	$1C_1$	2.00
	1.60	$1B_2$	
	1.90	$1A_3$	
	1.60	$2B_1$	
	1.90	$2A_2$	
	1.90	$3A_1$	
Marion			
Pitt.			
CT-14	1.90	$1A_3$	10.30
	1.30	$2B_2$	
	1.90	$2A_3$	
	1.40	$3A_2$	
	1.90	$3A_3$	
Marion			
Pitt.			
BM-25	1.30	$1B_3$	10.30
	1.60	$1A_4$	
	1.60	$2A_4$	
	1.40	$3A_3$	
	1.60	$3A_4$	
Marion			
Pitt			
BM-28	1.40	$1A_4$	10.30
	1.60	$2A_4$	
	1.30	$3B_3$	
	1.60	$3A_4$	
Preston			
Freeport			
CT-21	1.40	$1A_1$	3.50
	1.90	$1A_2$	
	1.90	$2A_1$	
	1.90	$3A_1$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
WEST VIRGINIA			
Monongalia			
Pitt.			
BM-19	1.40	$1B_2$	10.30
	1.60	$1A_3$	
	1.60	$2A_2$	
	1.60	$3A_2$	
Monongalia			
Pitt.			
BM-21	1.40	$1A_3$	10.30
	1.60	$1A_4$	
	1.60	$2A_3$	
	1.30	$3B_2$	
	1.60	$3A_3$	
Monongalia			
Sewickley			
BM-87	1.30	$1C_5$	3.60
	1.30	$2C_4$	
	1.30	$3C_4$	
Monongalia			
Waynesburg			
BM-103	1.30	$1C_1$	2.30
	1.60	$1A_2$	
	1.30	$2C_1$	
	1.60	$2A_2$	
	1.30	$3C_1$	
	1.60	$3A_2$	
Monongalia			
Pitt.			
BM-26	1.30	$1B_5$	10.30
	1.30	$2B_5$	
	1.30	$3B_5$	
Harrison			
Pitt.			
BM-85	1.30	$1C_3$	10.30
	1.30	$2C_3$	
	1.40	$3A_3$	
	1.60	$3A_4$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
WEST VIRGINIA Harrison Pitt. BM-88	1.30	$1C_4$	10.30
	1.30	$2C_3$	
	1.30	$3C_3$	
	1.40	$3C_3$	
Harrison Pitt. BM-86	1.30	$1C_5$	10.30
	1.30	$2C_5$	
	1.30	$3B_5$	
Barbour M. Kitt. BM-83	1.30	$1C_1$	
	1.60	$1A_2$	
	1.60	$2A_1$	
	1.60	$2A_1$	
Barbour M. Kitt. BM-84	1.30	$1C_1$	
	1.40	$1B_3$	
	1.60	$1A_4$	
	1.30	$2C_1$	
	1.40	$2B_2$	
	1.60	$2A_3$	
	1.30	$3C_1$	
	1.60	$3A_2$	
Ohio Pitt. BM-42	1.30	$1C_4$	10.30
	1.30	$2C_4$	
	1.30	$3C_4$	

APPENDIX G

State County Seam Sample	Specific Gravity	Ranking	Original Reserve in Billion Tons
WEST VIRGINIA			
Ohio			
Pitt.			
BM-54	1.30	$1C_3$	10.30
	1.30	$2B_3$	
	1.30	$3B_3$	
	1.40	$3A_4$	
	1.30	$1C_3$	
	1.30	$2C_3$	
	1.40	$2A_4$	
	1.30	$3C_3$	
	1.40	$3A_4$	
Marshall			
Pitt.			
BM-24	1.30	$1C_5$	10.30
	1.30	$2C_4$	
	1.30	$3C_4$	
Marshall			
Pitt.			
BM-55	1.30	$1C_5$	10.30
	1.30	$2C_5$	
	1.30	$3C_5$	

APPENDIX H

TABLE VIII

Coal reserves of major seams in the states of Ohio, West Virginia and West Kentucky.

State	Major Seam	Original Reserve (in billion tons)
Ohio	Washington	900,042,000
	Waynesburg A	490,686,000
	Waynesburg 11	690,754,000
	Uniontown	1,380,168,000
	Meigs Creek	4,020,762,000
	Fishpot	440,746,000
	Redstone	796,257,000
	Pittsburgh	5,559,932,000
	Harlem	34,560,000
	Anderson	837,504,000
	Wilgus	173,000,000
	Mahoning	284,304,000
	Upper Freeport	4,180,771,000
	Lower Freeport	2,446,278,000
	Middle Kittanning	9,783,598,000
	Lower Kittanning	9,913,989,000
	Clarion	715,637,000
	Brookville	446,215,000
	Tionesta	180,288,000
	Bedford	308,928,000
	Upper Mercer	321,088,000
	Lower Mercer	328,312,000
	Quakertown	732,792,000
	Sharon	1,521,640,000

APPENDIX H

Total estimated original reserves of major seams in the state of Ohio is 46,488,251,000 tons. Seam thickness of 14" or greater has been considered. Coal reserves are found only in the eastern or southeastern part of the state.

State	Major Seam	Original Reserve (in billion tons)
West Virginia	Washington	3,400,000,000
	Waynesburg	2,300,000,000
	Sewickley	3,600,000,000
	Pittsburgh	10,300,000,000
	Bakerstown	2,000,000,000
	Upper Freeport	3,500,000,000
	Upper Kittanning	3,800,000,000
	L. Kittanning	10,000,000,000
	Stockton - Lewiston	3,800,000,000
	Coalburg	2,600,000,000
	Winifrede	3,300,000,000
	Chilton	3,000,000,000
	Ceder Grove	3,800,000,000
	Alma	3,100,000,000
	No. 2 Gas	7,000,000,000
	Eagle	3,900,000,000
	Sewell	5,800,000,000
	Beckley	1,900,000,000
	Fire Creek	2,400,000,000
	Pocahontas #3	2,400,000,000

Total estimated original reserves of coals in the state of West Virginia is 102,600,000,000 tons. The 20 major seams constitute a total estimated reserve of 82 billion tons, out of which about 40 billion tons could ultimately be recovered.

APPENDIX H

State	Major Seam	Original Reserve (In billion Tons)
Western Kentucky -	No. 6	0.63
	No. 9	8.02
	No. 11	1.73
	No. 12	1.18
	No. 14	0.16

According to the Kentucky Geological Survey, reserves shown for the major seams, No. 9, No. 11 are more than indicated above. The above reserves figures given by TVA are the result of a reconnaissance study done by TVA and Kentucky Geological Survey and, according to the Kentucky Geological Survey, are considered to be on the low side.

APPENDIX I
TABLE IX

ESTIMATED ANNUAL OPERATING COST
(Exclusive of Start Up Costs)

		Annual Cost	% Total
Direct Labor		$ 740,600	48.0
Overhead (20% of Direct Labor)		$ 148,120	9.6
Direct Costs)other than labor)			
~~Intercom Service (Plant to Lab.~~	~~$6,000~~		
Software Programming	$ 10,000		
Recording Stations, Key P.	$ 11,000		
Data Phone	$ 12,000		
Input Devices-Terminal	$ 20,000		
Computer Time	$ 84,000		
Data Storages & C.R.T.	$ 5,000		
Microwave Services	$ 12,000		
Closed Circuit Tv	$ 11,000		
Xerox	$ 3,600		
Telephone	$ 2,400		
		$ ~~166,000~~ 171,000	10.7
Lab. Supply Costs			
Deionized Water	$ 16,000		
F-S Chemicals	$ 20,000		
Lab. Supplies	$130,000		12.7
Office Supplies	$ 30,000	$ 196,000	
Travel Costs		$ 15,000	1.0
T&A - 10% of Total Cost		$ 154,355	10.0
Profit (before taxes)-8% of Total Cost		$ 123,485	8.0
TOTAL		~~$1,543,560~~ $1,548,560	100.0

ESTIMATED START-UP COSTS

Labor			
Hiring Cost - 10% of Payroll		$ 69,060	
6 Months labor cost		$ 345,300	$ 414,360
Overhead (20% of labor)			82,870
Direct costs)other than labor)			
Microwave Services	$12,000		
Microwave Installation	$25,000		
Software	$10,000		
Data Phone	$10,000		
Computer Time	$20,000		
Telephone	$ 2,000		
Truck	$ 1,200		
Wiring & Plumbing	$ 9,000		$ 89,200
Laboratory Supplies			$ 25,000
Office Supplies			$ 15,000
Travel Costs			$ 10,000
Preliminary Eng.			$ 18,470
T&A - 10% of Total Cost			$ 79,865
Profits (before taxes) - 8% of Total Cost			$ 63,895
			$ 798,660

APPENDIX I

TABLE IX Page 3

SAMPLING -- ANALYSIS MATRIX

DEPARTMENT	LABOR No. People	EQUIPMENT INVESTMENT	UNIT ANNUAL WAGES	ANNUAL LABO COST (Direc
Sampling	7	18,595.00	$ 11,200.00	
Dewatering	2	23,299.00	11,200.00	
Drying	3	156,700.00	11,200.00	
Screening	4	24,055.50	11,200.00	
F & S	6	74,494.00	11,200.00	
Grinding Pulverizing	5	24,794.55	11,200.00	
Chief Chemist	1		14,000.00	
Analysis (Lab)	10	167,881.00	11,200.00	$428,400.00
Computer	2		16,000.00	32,000.00
Clerical	6		6,500.00	39,000.00
Office (3 Foreman) (1 Steno)	4	20,786.00	14,000-8,000	50,000.00
Plant Mgr.	1		18,000.00	18,000.00
Maint. (Janitor Mechanic)	2		11,200.00	22,400.00
Total (Daily Runs)	53			$589,800.00
Swing Shift	9		11,200.00	100,800.00
Chicago Office Consultation				50,000.00
TOTAL	62	~~$510,604.95~~ $510,605.05		$740,600.00

APPENDIX I

McNALLY PITTSBURG 30-62521
H.E.W. CONTRACT No. PH-22-68-59

SAMPLING Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
63		Bins for Material, Dynalab No. 1T96,97		130.00	8,190.00
300		Tubs		4.00	1,200.00
1		Toledo 2181 Scales with Digital Readout and wheeled stand & pan		3,400.00	3,400.00
10		Dollies		200.00	2,000.00
4		2 wheel carts		100.00	400.00
150		Sample Cans (Milk)		16.00	2,400.00
300 ↙		Canvas Sample Bags		3.35	1,005.00
				TOTAL	$18,595.00

APPENDIX I

McNALLY PITTSBURG 30-62521
H.E.W. CONTRACT NO. PH-22-68-59

FILTRATION

Quantity	Catalog No.	Description	Elect.	Floor Space	Unit Price	Total Price
20		Denver-2' x 2' Simplex Lab. Pan Filters			786.00	15,720.00
1		Denver-Nash Model CL-403 Vaccuum Pump	25 hp, 3 phase, 208V		4329.00	4,329.00
1		Dings Submerged Belt Wet Type Magnetic Separator Model XW-5	208 V 3 phase 400 Watts-110DC		3250.00	3,250.00
					TOTAL	23,299.00

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McNALLY PITTSBURG S0-62521
H.E.W. CONTRACT NO. PH-22-68-59

DRYING

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
1		Microwave Unit 3 Phase	200 KVA (440 Volt)	150,000.00	150,000.00
500		Trays		5.00	2,500.00
1		Mark V Radarange	1300 Watts	3,000.00	3,000.00
2		Small Radarange	500 Watts ea.	500.00	1,000.00
1		Table, Custom Built			200.00
					$156,700.00

APPENDIX I

McNALLY PITTSBURG SO-62521
H.E.W. Contract No. PH-22-68-59

SCREENING

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
2		Metler P-5000 Balance		1,000.00	2,000.00
2		Toledo 9955 Scales with Remote Data Transfer & Digital Readout		4,700.00	9,400.00
2	F-5022A	Standing Type Desks McMaster Carr		60.00	120.00
5	CL-325 H	Testing Screens, Gilson c Hydraulic Clamping 110 V, 60 C	1-1/3 HP	656.50✓	3,282.50✓
5	CL-337	Anti-vibration mountings		350.00	1,750.00
5	CL-334	Tray Rack, Gilson		33.00✓	165.00
5	CL-335	Door Enclosure, Gilson		27.50✓	137.50
10✓	CL-331	Test-Timers, Gilson		15.00✓	150.00
5	CL-326	1-1/2" Screen		30.00	150.00
5	CL-326	3/4"		30.00	150.00
5	CL-326	3/8"		30.00	150.00
5	CL-327	14		38.00✓	190.00
5	CL-328	28		42.00	210.00
5✓	CL-340	Rotaps rigged for Wet Screening	-1/4 HP, 110V, 60C	900.00	4,500.00
5 Sets		8" Sieves 14,28,48,60,100,150, 200,250, 325		300.00/Set	1500.00
1		Bench, Custom Built			200.00
					$24,055.00

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McNALLY PITTSBURG 30-62521
H.E.W. CONTRACT NO. PH-22-68-59

FLOAT & SINK

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
10		Float & Sink Cabinets-Custom		Est. 400.00	4,000.00
2		Budget Electric Hoists	1 HP, 208 V each	375.00	750.00
2		Coarse F & S Cabinets, Custom		1000.00	2,000.00
10		Float & Sink Tanks-Custom		250.00	2,500.00
4		Drum Lifters & Supports		180.00	720.00
350'		5/8" Teflon Tubing		6.60/ft	2310.00
3		Exhaust Fan	5 HP,208 V	750.00	2,250.00
60		Float & Sink Separators		45.00	2,700.00
4	POM-964	Batch Oven with Roll-in Racks Blue M	208V, 3 phase 14 KW each	9,766.00✓	39,064.00
		Racks & Apparatus-Custom		2,000.00	2,000.00
		F & S Ventilation with positive motor driven dampers and chemical traps		3,000.00	3,000.00
2		Toledo 9955 Scales with Remote Data Transfer & Digital Readout		4,700.00	9,400.00
2		Metler P-5000		1,000.00	2,000.00
2	F-5022A	Standing Type Desks-McMaster Carr		60.00	120.00
10	21-3980	Pump, Liquid, Randolph		143.00	1,430.00
1		Torsion Solution Balance		250.00	250.00
				TOTAL	$74,494.00

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McNALLY PITTSBURG SO-62521
H.E.W. CONTRACT NO. PH-22-68-59

Sample Prep.

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
1		Denver-Jaw Crusher 5" X 6"	5 HP, 208 V	1650.00	1,650.00
1	Model 1700	Holmes Crushing & Cutting Station	7-1/2 HP 3 phase, 208 V	6221.25	6,221.25
1		Holmes Slope Hoist for above	5 HP, 3 Phase 208 Volt	3125.00	3,125.00
1	Model 401	Holmes Crusher, 10 X 15	7-1/2 HP, 3 Phase, 208 V	1354.50	1,354.50
1	Model 201	Holmes Crusher 7 X 6	2 HP-3phase 208 Volt	934.50	934.50
2	Model 500	Holmes Pulverizer, C Vain Speed Control	1 HP each 115 Volt	693.00	1,386.00
2	91-7970	Riffle, Holmes Model 15, Hopper-12-5/8' x 9-7/8" x 23-1/4" High		148.05	296.10
		Work Tables-Custom Built		500.00	500.00
1		Refuse Conveyor		Est. 3000.00	3,000.00
2	Model 5	Holmes Riffle & Feed Hopper		165.90	331.80
6✓	Model 11	Holmes Riffle Buckets, 1" Openings		57.75	346.50
6✓	Model 12,	Holmes Riffle Buckets, 1/2" Openings		67.20	403.20
6✓	2B50	Containers for Riffles		33.60	201.60
2	91-6420	Preiser-Crusher, Bucking Board Type Model B, 24" X 36"		195.25✓	390.50
2	91-6310	Preiser-Filling Funnel, Coal Sample Bottle PS-800		41.80✓	83.60
30✓	21-5783	Respirator, Face Masks + Refills		6.00✓	180.00
	208V-	Preparation Dust Collection System	5 HP,	4000.00	4,000.00
60✓		Hard Hats		6.50✓	390.00
				TOTAL	$24,794.55

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McNALLY PITTSBURG SO-62521
H.E.W. CONTRACT NO. PH-22-68-59

LAB.

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
4	WB-1421	Work Bench-Style 3, 60"		220.00	880.0
1	91-2071	Preiser Moisture Ovens	32KW-208 3PH	1611.00 ✓	1,611.0
32 ✓	91-2265-65	Trays		6.00 ✓	192.0
2	20-6325	Residual Moisture Ovens-120V 1400 W		475.00 ✓	950.0
1 ✓		Mettler P-5000 Balance		1000.00 ✓	1,000.0
1		Sample Mixer-Custom Made		400.00	400.0
4	LCU 32-H	Rascher & Betzold-Corner Cab.		139.00	556.0
4		Colorceran Tops for same		119.00	476.0
4	SU1CC-59	Colorceran Sinks		450.00	1,800.0
30	PAC-6B	Fume Hoods c̄ Plastic Exterior		1,700.00	51,000.0
30	D9C	Exhaust Blowers for above	1/3 HP	157.00	4,710.0
30	D8A	Air Supply Blowers	1/6 HP	77.00	2,310.0
8	WB-1393	72" Cabinets & Sliding Doors		273.00	2,184.0
10 ✓	LK47H	Cabinets		200.00	2,000.0
10 ✓		Colorceran Tops for above		90.00	900.0
6	BM-47	Extra Heavy Balance Tables		220.00	1,320.0
6	LRUC2230	Chairs		52.00	312.0
30		Gas, Electrical, Water Serv. for Hoods		140.00	4,200.0
12		Calorimeter Heaters, Parr 1501	500W,115V	158.00	1,896.0
100	6795	Pyroceran Electric Hotplate, Model PC-351	600W,120V	119.00	11,900.0
		Truck		3,000.00	3,000.0

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TABLE IX, Page 11

McNALLY PITTSBURG SO-62521
H.E.W. CONTRACT NO. PH-22-68-59

PAGE II

LAB.

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
6		Balances, Sortorius Model 2603		1,000.00	6,000.0
1	Model D-1	500 Gram glass tank, Denver Lab. Flotation Machine		740.00	740.0
		Lab. Ventilation Systems less Blowers		10,000.00	10,000.0
		Sectional Steel Shelving		1,500.00	1,500.0
28		6' Filter Racks, Custom made		150.00	4,200.0
10		Stools		60.00	600.0
6	Model 8600 F-2	Electric Furnaces c̄ Inconel Muffles	208 V, 3 PH 6 KW	1,910.00 ✓	11,460.0
6	Model 8600 F-2	Electric Furnaces c̄ Inconel Muffles c̄ West	208V, 3 PH 6 KW	3,160.00 ✓	18,960.0
4		Spare Thermocouples		15.00	60.0
6		Spare Heating Elements		180.00	1,080.0
10 ✓		Laboratory Carts		120.00	✓ 1,200.0
12 ✓	10-8427	Automatic Burets		75.00 ✓	900.0
14		Johnson Gas Burners		600.00	8,400.0
1	Model C-44	Hobart Dishwasher	208 V, 3 PH, 15 KW Heater 1-1/2 HP Motor	7,744.00	7,744.0
10		CO_2 Fire Extinguishers (Lab & Test Area in Plant)		140.00	1,400.0
1		First Aid Emergency Kit			40.0
					→ $167,881.0

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McNALLY PITTSBURG SO-62521
H.E.W. CONTRACT NO. PH-22-68-59

OFFICE

Quantity	Catalog No.	Description	Electrical	Unit Price	Total Price
3		Friden Electronic Calculators	110 V.	1,000.00	3,000.00
5 ✓		IBM Typewriters		600.00	3,000.00
6 ✓		Manager Desk & Chairs		350.00	2,100.00
6 ✓ UT	UT70-31	Tables		165.00	990.00
8 ✓		Files R&B, Horizontal S Drawer EE-3 letter Cole		339.30	2,714.40
2 set		Shelves, Book		100.00	200.00
2		Steel Storage Cabinet R&B $76 Cole		120.55	241.10
7 ✓		Desks, Steno		250.00	1,750.00
7 ✓		Chairs R&B WS5		91.50	640.50
1 ✓		Temperature-Hunidity Indicator			
		Conference Room Furnishings		Est.	5,000.00
		Lobby Furniture			600.00
2 ✓		Time Clocks		250.00	500.00
					$20,786.00

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APPENDIX I

TABLE IX

OPERATING SUPPLIES
REQUIRED FOR START-UP AND THE FIRST 4 MONTHS' OPERATION

FLOAT & SINK		RASCHER & BETZOLD		
72	12-7915	Funnels	9.25	666.00
4 Sets	13-1755	Hydrometers	31.00	124.00
		Sieves		10.00
		Clamps		50.00
		Brushes		20.00
800 Boxes		Grade X-Filter Paper	2.40	1920.00
8	11.7635	Hydrometer Cylinders	2.10	16.80
35,000		Jacks		125.00
120 gross	8oz. bottles		10.25/gr	1230.00
120 gross	16 oz. bottles		14.00/gr	1680.00
			Total	$5,841.80

FLOAT & SINK CHEMICALS				
1000 gallons		White Gas	.35/gal	350.00
20 Drums	700#	Perk	115.00/drum	2300.00
6 Drums	990#	Ethylene Dibromide	33.50¢/#	1989.90
5 Drums (5 Gal.)	100#	Bromoform, Ind. Grade	$2.25/#	1125.00
5 Drums (5 Gal.)	125#	Acetylene Tetrabromide	.79¢/#	493.75
10-5 gals	32.8#	Acetone, Tech.	10.75/gal.	537.50
			TOTAL	$6,796.15

TOTAL FLOAT & SINK SUPPLIES $12,637.95

OPERATING SUPPLIES.

Required for Start-up and the First 4 months' operation

LABORATORY

				Cat.664	As Listed
21	Cases (48 to case)	R&B 10-3030	400ml Beakers	41.28/C	866.88
20	Cases (12 to case)	10-6360	Weighing bottles	22.56	451.20
200			Weighing Tins	@ .35	70.00
9	Pkgs. (48 to Pkge)	12-7735	Funnels 60°	35.04	315.36
2	Cases (144 to case)	12-6210	Erlenmeyer Flask	64.80	129.60
200		11-6090	Cold Finger Condenser #6	4.55	910.00
2	gross	14-9420	Watch Glasses 4" Dia.	38.00	76.00
2	gross	14-9460	Watch Glasses 65 mm	19.44	38.88
24	Pkgs. (36 to pkge.)	11-6675	Coors Crucibles 3A	24.02	576.48
12	Pkgs. (36 to pkge.)	11-6675	Coors Crucibles 4	22.01	264.12
12	Thermometers	14-4490	Thermometers	2.20	26.40
12	Dessicators	12-1140	Dessicators 250 mm	34.89	418.68
320	Boxes	12-4645	#1 Filter Paper 12.5 cm.	0.60	192.00
320	Boxes	12-4770	Whatman #30, 12.5cm Filter Paper	@ 1.66	531.20
16	Boxes	12-5320	Ashless Pulp S & S	2.50	40.00

Flasks, Bottles, Wash Bottles, Graduates, Ringstands, etc. Spatulas, Aprons, Gloves, Misc. operating supplies Brushes, Weights	3,500.00

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OPERATING SUPPLIES

Required for start-up and the first 4 month's operation

E. H. Sargent & Co. - 1967 Catalog

LABORATORY

10 Cases	HCL	13.00	130.00
6 Cases	HNO_3	14.21	85.26
24 x 1 pt.	H_2O_2, CP 30% BK2189	3.54	84.96
6 Cases (6 x 4)	NH_4OH, ACS	11.64/case	69.84
12 x 1#	NH_4CL	1.54/#	18.48
2	$SnCL_2$, 250 gm.	4.45	8.90
10 (32 oz)	$HgCL_2$ Solution	4.50	45.00
20 (32 oz)	$K_2Cr_2O_7$ Solution	2.25	45.00
2 cases (6 x 9#)	H_2SO_4	14.36/Case	28.72
2 cases (6 x 9#)	H_3PO_4	4.08 ea.	48.96
2 Bottles (16 oz)	$AgNO_3$ Solution	2.00	4.00
1	Water Testing Equipment		1700.00
			$10,675.92

OFFICE SUPPLIES

Paper & Office supplies	$15,000.00